FIG. 1

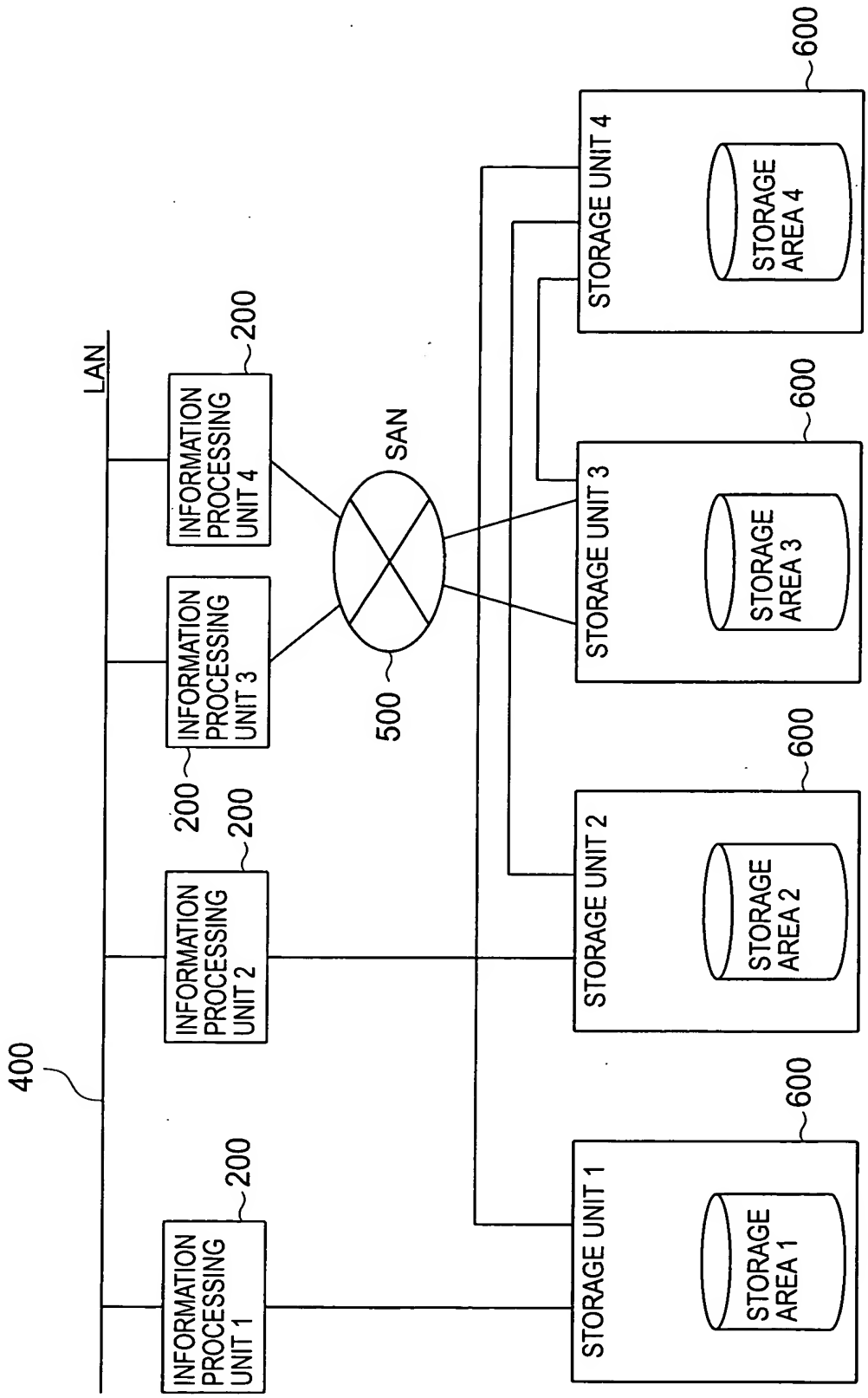

LAN
400
INFORMATION PROCESSING UNIT 1
INFORMATION PROCESSING UNIT 2
INFORMATION PROCESSING UNIT 3
INFORMATION PROCESSING UNIT 4
200
200
200
200
SAN
500
STORAGE UNIT 1
STORAGE UNIT 2
STORAGE UNIT 3
STORAGE UNIT 4
STORAGE AREA 1
STORAGE AREA 2
STORAGE AREA 3
STORAGE AREA 4
600
600
600
600

FIG. 2

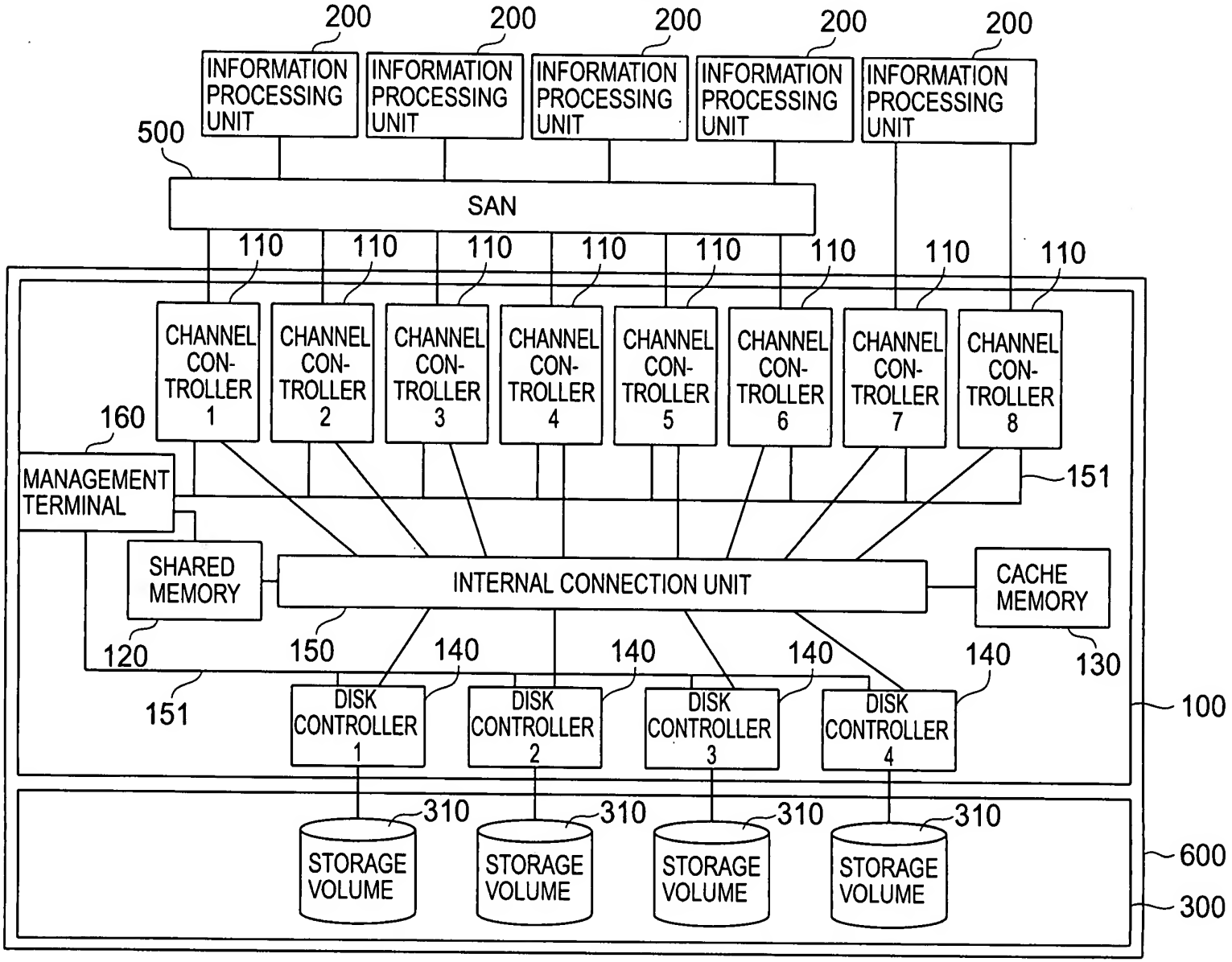

200
INFORMATION PROCESSING UNIT
500
SAN
110
CHANNEL CON-TROLLER 1
CHANNEL CON-TROLLER 2
CHANNEL CON-TROLLER 3
CHANNEL CON-TROLLER 4
CHANNEL CON-TROLLER 5
CHANNEL CON-TROLLER 6
CHANNEL CON-TROLLER 7
CHANNEL CON-TROLLER 8
160
MANAGEMENT TERMINAL
151
SHARED MEMORY
INTERNAL CONNECTION UNIT
CACHE MEMORY
120
150
140
130
DISK CONTROLLER 1
DISK CONTROLLER 2
DISK CONTROLLER 3
DISK CONTROLLER 4
100
310
STORAGE VOLUME
600
300

FIG. 3

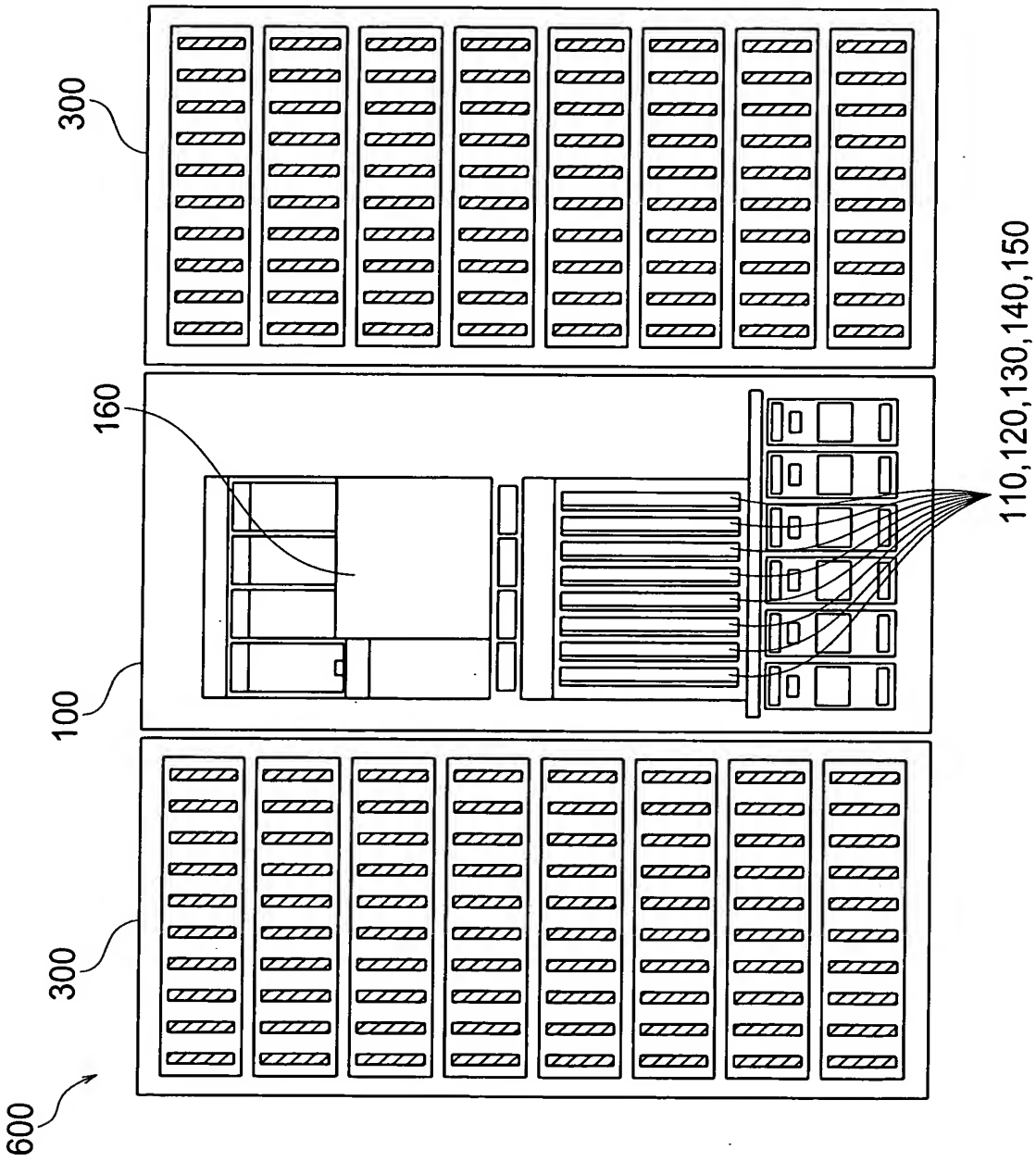


FIG. 4

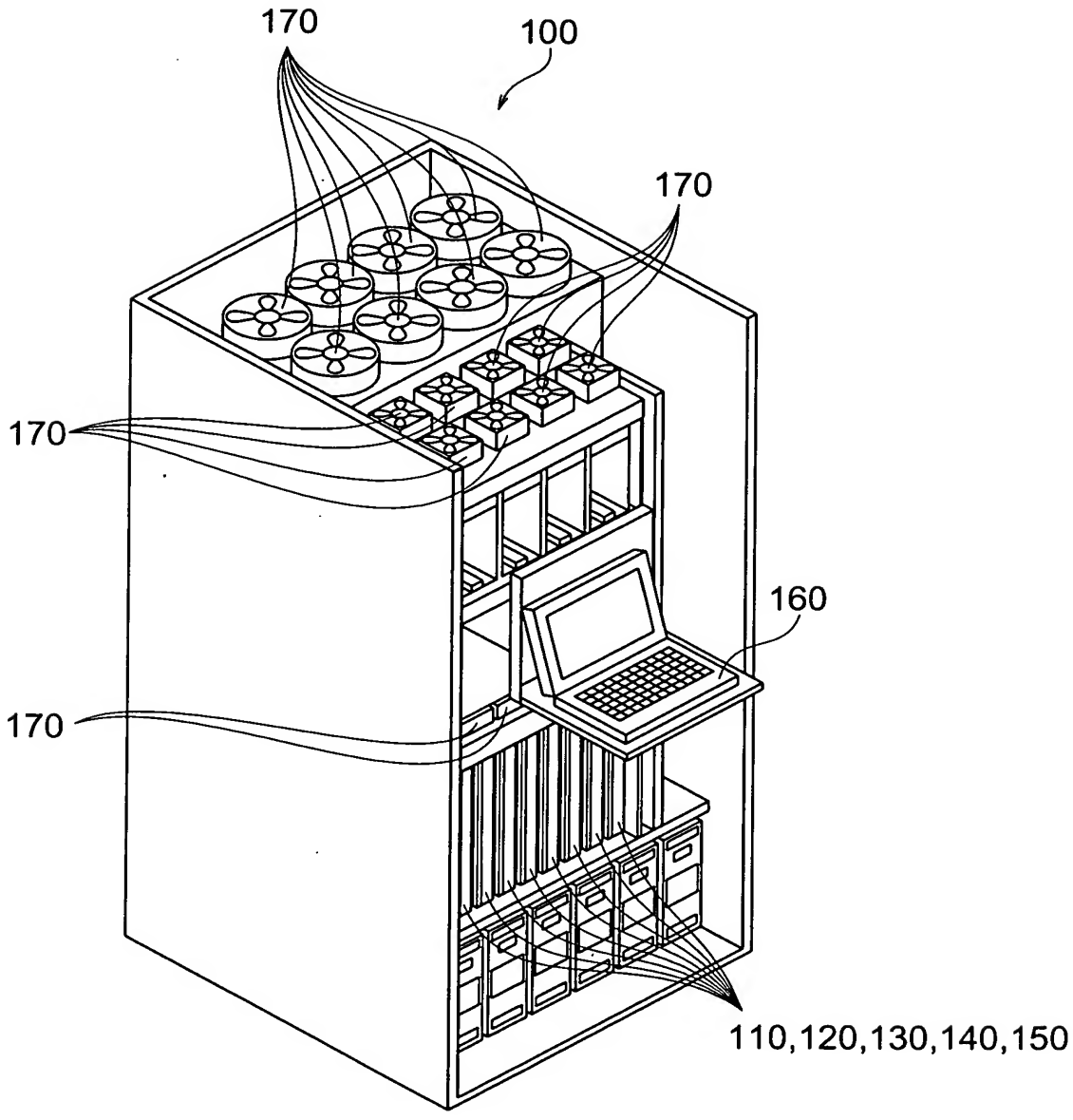


FIG. 5

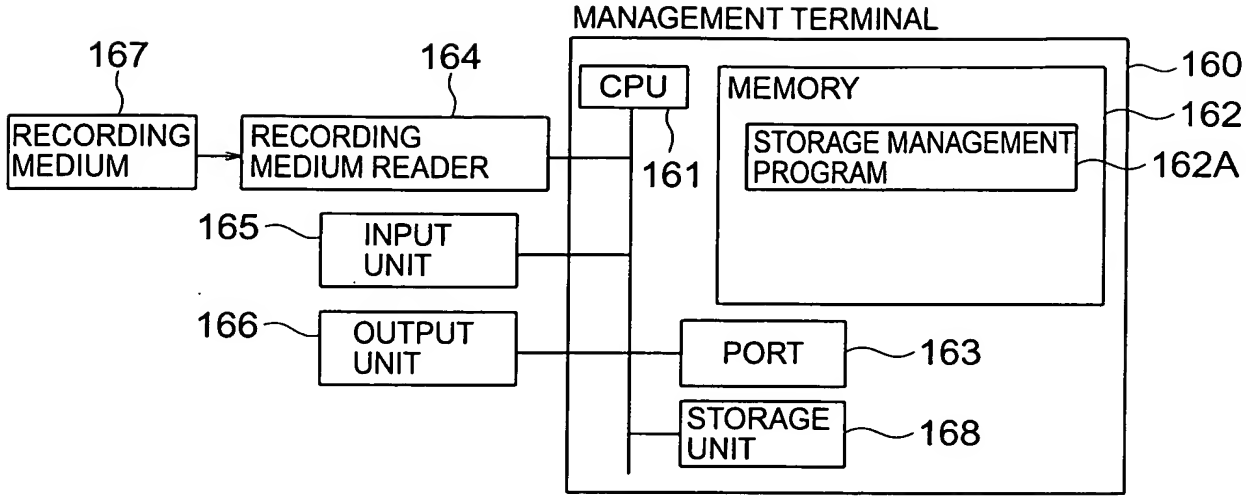

MANAGEMENT TERMINAL
167
164
RECORDING MEDIUM
RECORDING MEDIUM READER
CPU
161
MEMORY
160
162
STORAGE MANAGEMENT PROGRAM
162A
165
INPUT UNIT
166
OUTPUT UNIT
PORT
163
STORAGE UNIT
168

FIG. 6

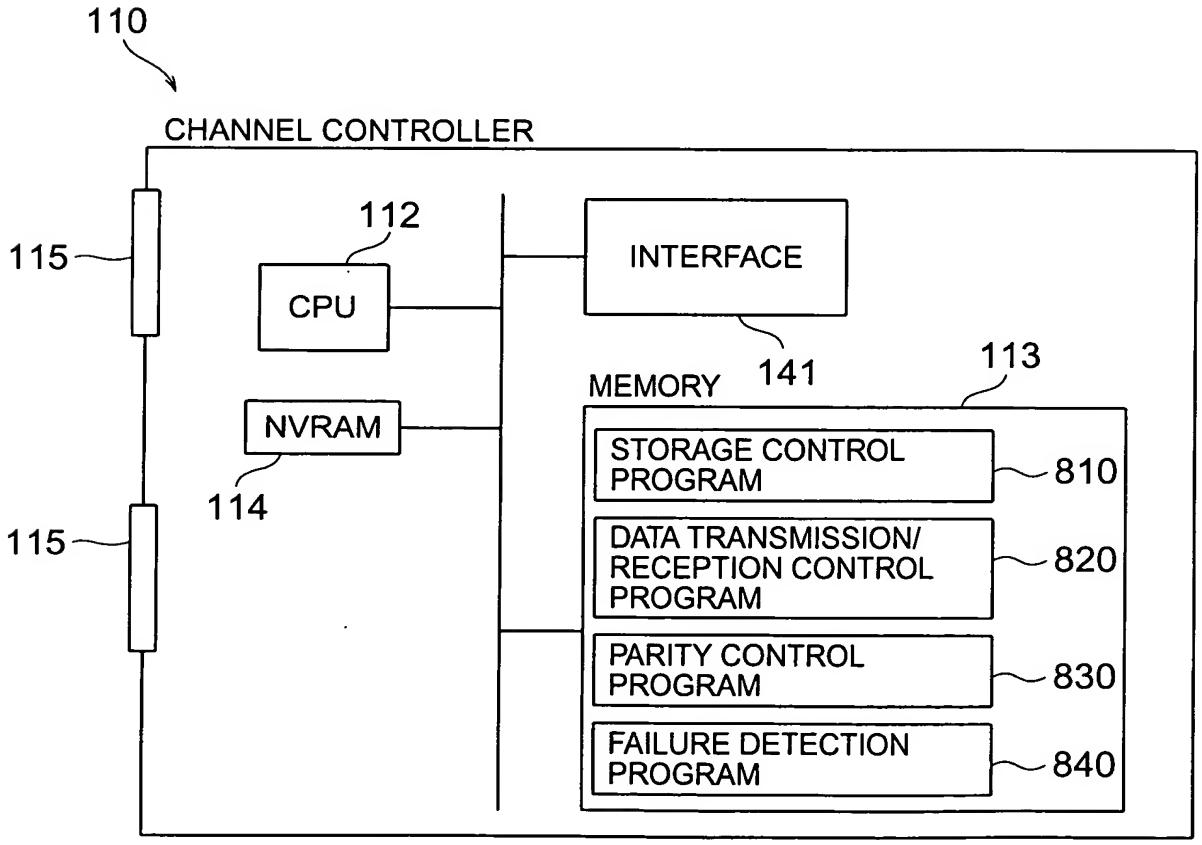

110
CHANNEL CONTROLLER
115
112
CPU
INTERFACE
141
113
MEMORY
NVRAM
114
115
STORAGE CONTROL PROGRAM
810
DATA TRANSMISSION/ RECEPTION CONTROL PROGRAM
820
PARITY CONTROL PROGRAM
830
FAILURE DETECTION PROGRAM
840

FIG. 7

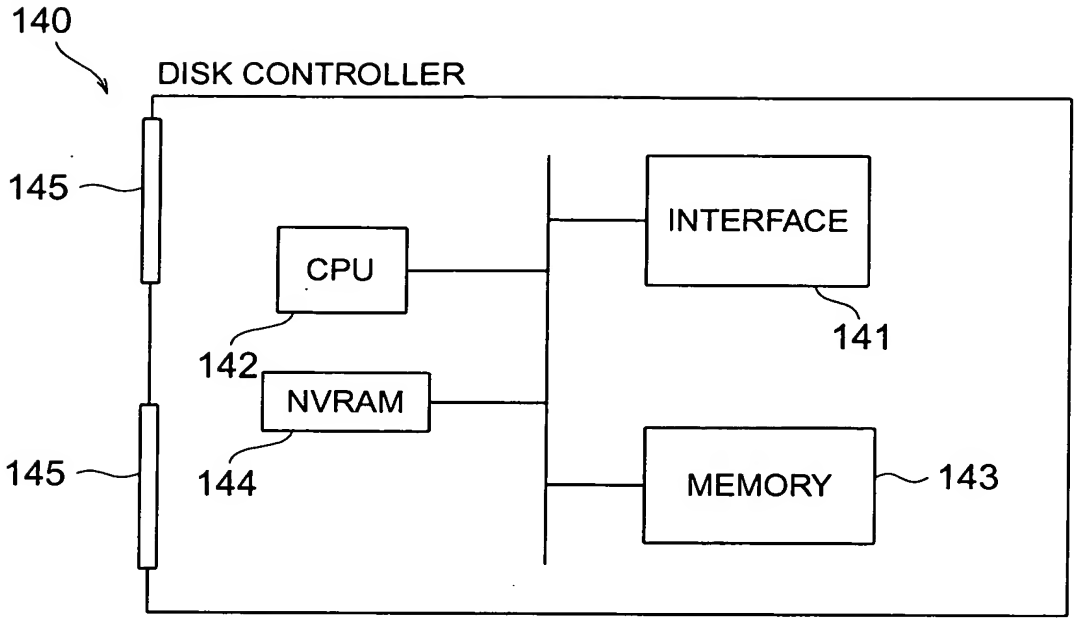

140
DISK CONTROLLER
145
145
CPU
142
NVRAM
144
INTERFACE
141
MEMORY
143

FIG. 8

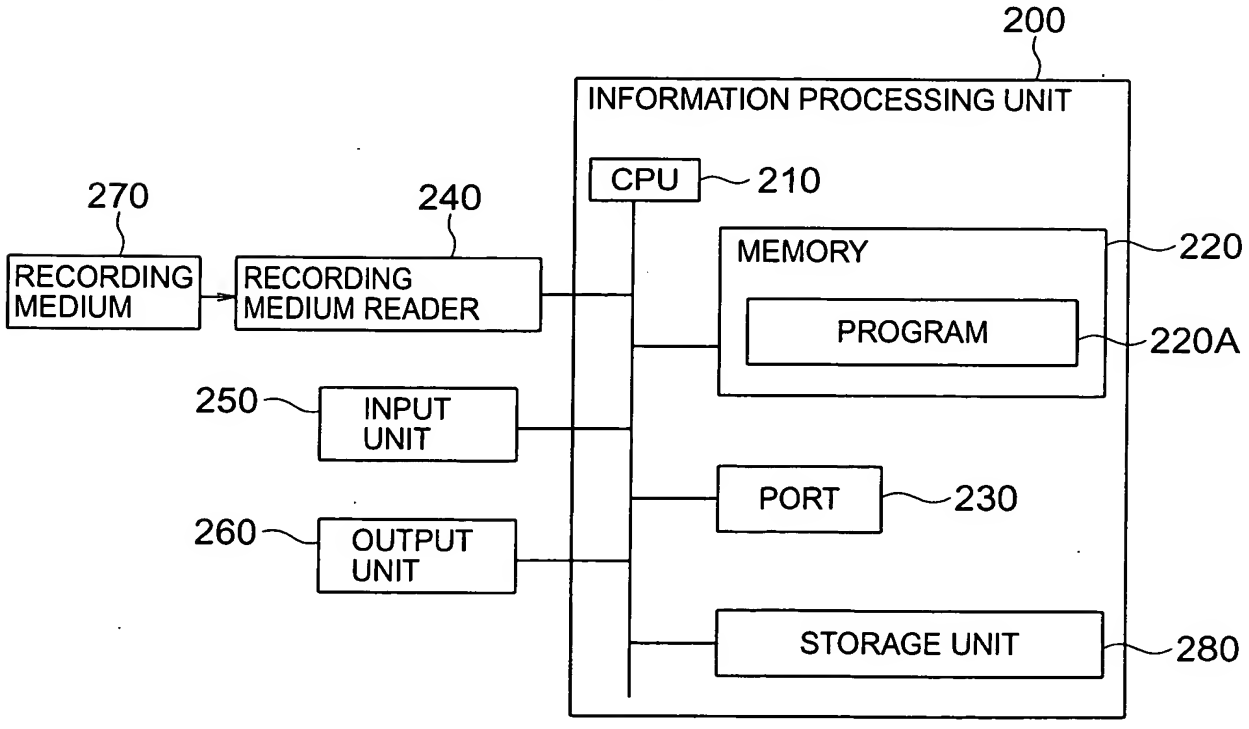

200
INFORMATION PROCESSING UNIT
CPU
210
MEMORY
220
PROGRAM
220A
270
RECORDING MEDIUM
240
RECORDING MEDIUM READER
250
INPUT UNIT
260
OUTPUT UNIT
PORT
230
STORAGE UNIT
280

FIG. 9

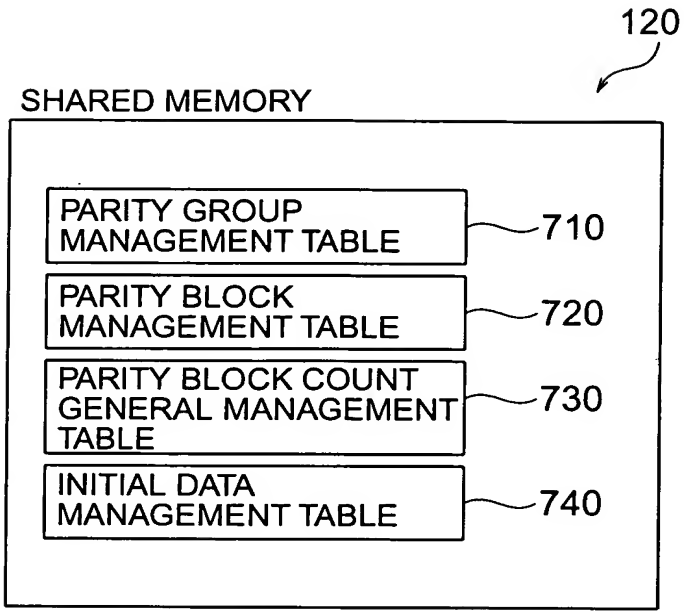


FIG. 10

710

PARITY GROUP MANAGEMENT TABLE

DATA STORING STORAGE UNIT	STORAGE UNIT 1, STORAGE UNIT 2, STORAGE UNIT 3
PARITY STORING STORAGE UNIT	STORAGE UNIT 4

FIG. 11

720

PARITY BLOCK MANAGEMENT TABLE

PARITY BLOCK LENGTH = 512 BYTES	
NUMBER OF PARITY BLOCKS = 800000	
LOGICAL VOLUME NUMBER	FIRST PARITY BLOCK NUMBER
0000	0
0001	4096
0002	16384
0003	40000
0004	81920
⋮	⋮

FIG. 12

730

PARITY BLOCK COUNT
GENERAL MANAGEMENT TABLE

STORAGE UNIT	NUMBER OF PARITY BLOCKS
STORAGE UNIT 1	500000
STORAGE UNIT 2	600000
STORAGE UNIT 3	700000
STORAGE UNIT 4	800000

FIG. 13A

740

INITIAL DATA MANAGEMENT TABLE

STORAGE UNIT	RECALCULATION
STORAGE UNIT 1	OFF
STORAGE UNIT 2	OFF
STORAGE UNIT 3	ON
⋮	⋮

FIG. 13B

740

INITIAL DATA MANAGEMENT TABLE

STORAGE UNIT	RECALCULATION	RECALCULATION
STORAGE UNIT 1	OFF	—
STORAGE UNIT 2	OFF	—
STORAGE UNIT 3	ON	123456
⋮	⋮	⋮

FIG. 13C

740

INITIAL DATA MANAGEMENT TABLE

STORAGE UNIT	RECALCULATION
STORAGE UNIT 1	OFF
STORAGE UNIT 2	OFF
STORAGE UNIT 3	ON
⋮	⋮

PARITY BLOCK NUMBER	RECALCULATION COMPLETED
0	COMPLETED
1	NOT COMPLETED
2	COMPLETED
⋮	⋮
699999	COMPLETED

FIG. 14

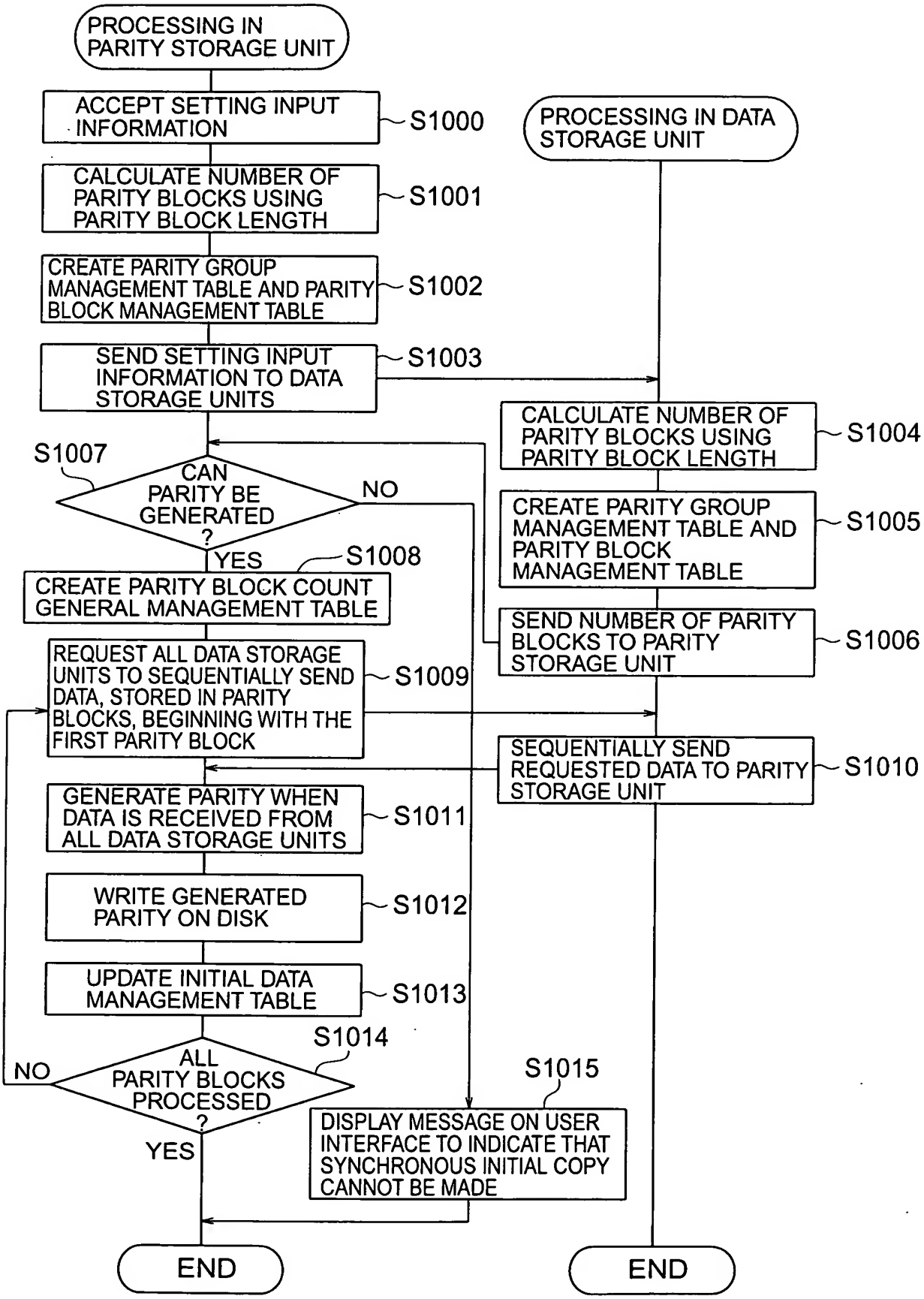

PROCESSING IN PARITY STORAGE UNIT
ACCEPT SETTING INPUT INFORMATION
S1000
CALCULATE NUMBER OF PARITY BLOCKS USING PARITY BLOCK LENGTH
S1001
CREATE PARITY GROUP MANAGEMENT TABLE AND PARITY BLOCK MANAGEMENT TABLE
S1002
SEND SETTING INPUT INFORMATION TO DATA STORAGE UNITS
S1003
PROCESSING IN DATA STORAGE UNIT
CALCULATE NUMBER OF PARITY BLOCKS USING PARITY BLOCK LENGTH
S1004
CREATE PARITY GROUP MANAGEMENT TABLE AND PARITY BLOCK MANAGEMENT TABLE
S1005
SEND NUMBER OF PARITY BLOCKS TO PARITY STORAGE UNIT
S1006
S1007
CAN PARITY BE GENERATED ?
NO
YES
S1008
CREATE PARITY BLOCK COUNT GENERAL MANAGEMENT TABLE
REQUEST ALL DATA STORAGE UNITS TO SEQUENTIALLY SEND DATA, STORED IN PARITY BLOCKS, BEGINNING WITH THE FIRST PARITY BLOCK
S1009
SEQUENTIALLY SEND REQUESTED DATA TO PARITY STORAGE UNIT
S1010
GENERATE PARITY WHEN DATA IS RECEIVED FROM ALL DATA STORAGE UNITS
S1011
WRITE GENERATED PARITY ON DISK
S1012
UPDATE INITIAL DATA MANAGEMENT TABLE
S1013
S1014
ALL PARITY BLOCKS PROCESSED ?
NO
YES
S1015
DISPLAY MESSAGE ON USER INTERFACE TO INDICATE THAT SYNCHRONOUS INITIAL COPY CANNOT BE MADE
END
END

FIG. 15

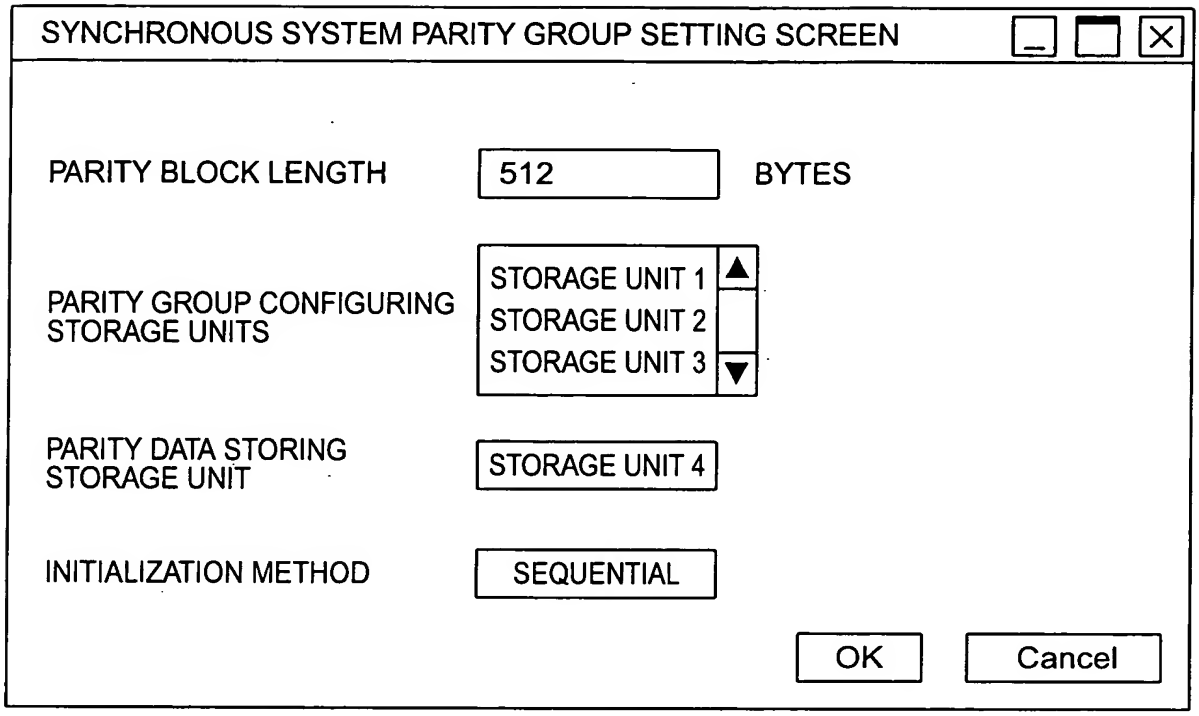

SYNCHRONOUS SYSTEM PARITY GROUP SETTING SCREEN
PARITY BLOCK LENGTH
512
BYTES
PARITY GROUP CONFIGURING STORAGE UNITS
STORAGE UNIT 1
STORAGE UNIT 2
STORAGE UNIT 3
PARITY DATA STORING STORAGE UNIT
STORAGE UNIT 4
INITIALIZATION METHOD
SEQUENTIAL
OK
Cancel

FIG. 16A

PARITY STORAGE UNIT

PARITY BLOCK LENGTH = 512 BYTES	
STORAGE VOL#	FIRST PB#
0000	0
0001	4096
0002	16384
0003	40000
0004	81920
:	:

FIG. 16B

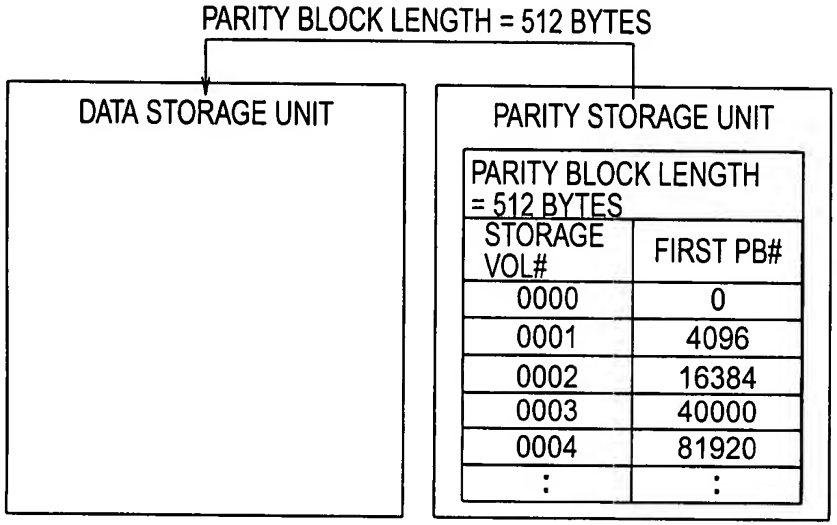


FIG. 16C

DATA STORAGE UNIT

PARITY BLOCK LENGTH = 512 BYTES	
STORAGE VOL#	FIRST PB#
0000	0
0001	5000
0002	8000
0003	10000
0004	20000
:	:

PARITY STORAGE UNIT

PARITY BLOCK LENGTH = 512 BYTES	
STORAGE VOL#	FIRST PB#
0000	0
0001	4096
0002	16384
0003	40000
0004	81920
:	:

FIG. 16D

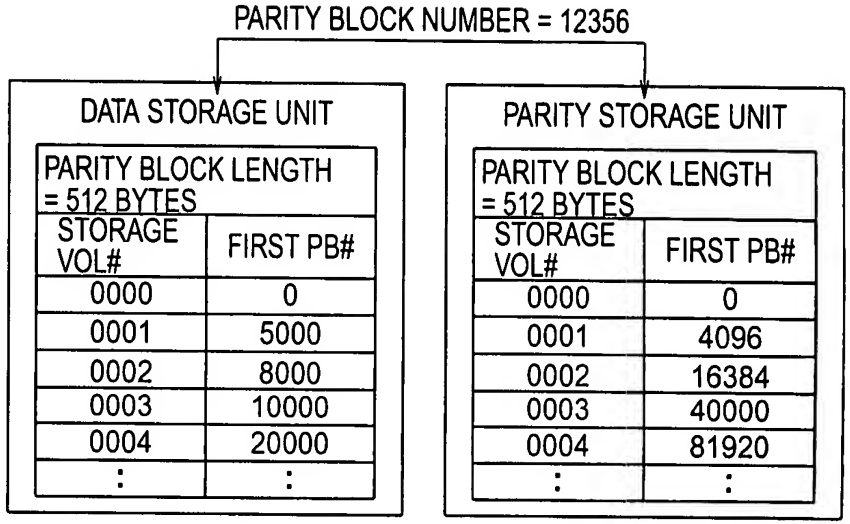


FIG. 17A

PARITY STORAGE UNIT

PARITY BLOCK LENGTH = 512 BYTES	
STORAGE VOL#	FIRST PB#
0000	0
0001	4096
0002	16384
0003	40000
0004	81920
:	:

FIG. 17B

PARITY BLOCK LENGTH = 512 BYTES

DATA STORAGE UNIT

PARITY STORAGE UNIT

PARITY BLOCK LENGTH = 512 BYTES	
STORAGE VOL#	FIRST PB#
0000	0
0001	4096
0002	16384
0003	40000
0004	81920
:	:

NUMBER OF PARITY BLOCKS = 8000000

FIG. 17C

DATA STORAGE UNIT

PARITY BLOCK LENGTH = 512 BYTES	
STORAGE VOL#	FIRST PB#
0000	0
0001	5000
0002	8000
0003	10000
0004	20000
:	:

NUMBER OF PARITY BLOCKS = 5000000

PARITY STORAGE UNIT

PARITY BLOCK LENGTH = 512 BYTES	
STORAGE VOL#	FIRST PB#
0000	0
0001	4096
0002	16384
0003	40000
0004	81920
:	:

FIG. 17D

NUMBER OF PARITY BLOCKS = 5000000

CONNECTABLE

DATA STORAGE UNIT

PARITY BLOCK LENGTH = 512 BYTES	
STORAGE VOL#	FIRST PB#
0000	0
0001	5000
0002	8000
0003	10000
0004	20000
:	:

NUMBER OF PARITY BLOCKS = 5000000

PARITY STORAGE UNIT

PARITY BLOCK LENGTH = 512 BYTES	
STORAGE VOL#	FIRST PB#
0000	0
0001	4096
0002	16384
0003	40000
0004	81920
:	:

NUMBER OF PARITY BLOCKS = 8000000

FIG. 18A

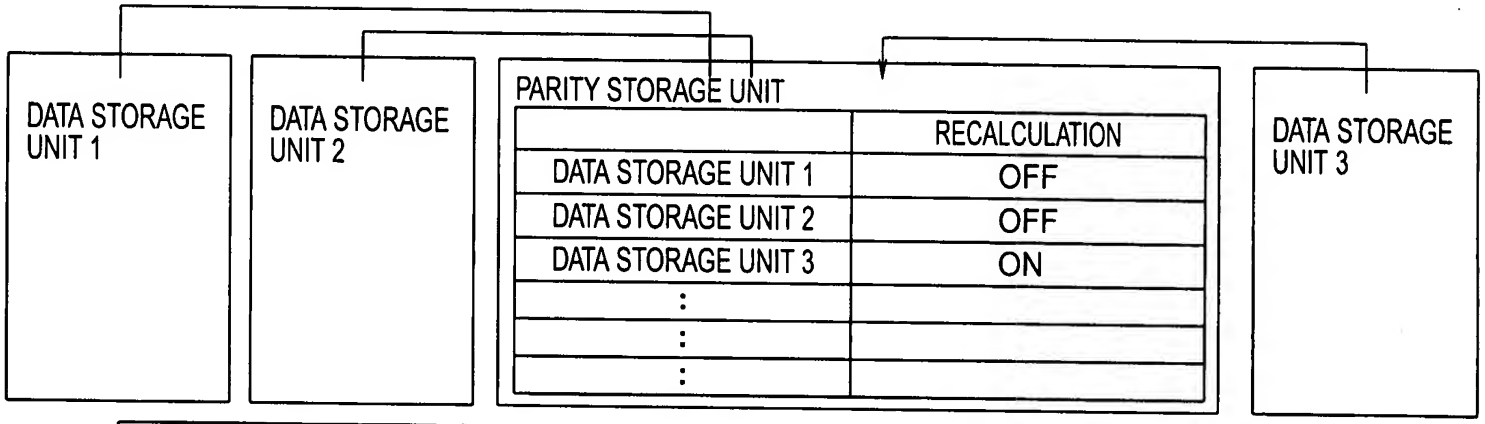


FIG. 18B

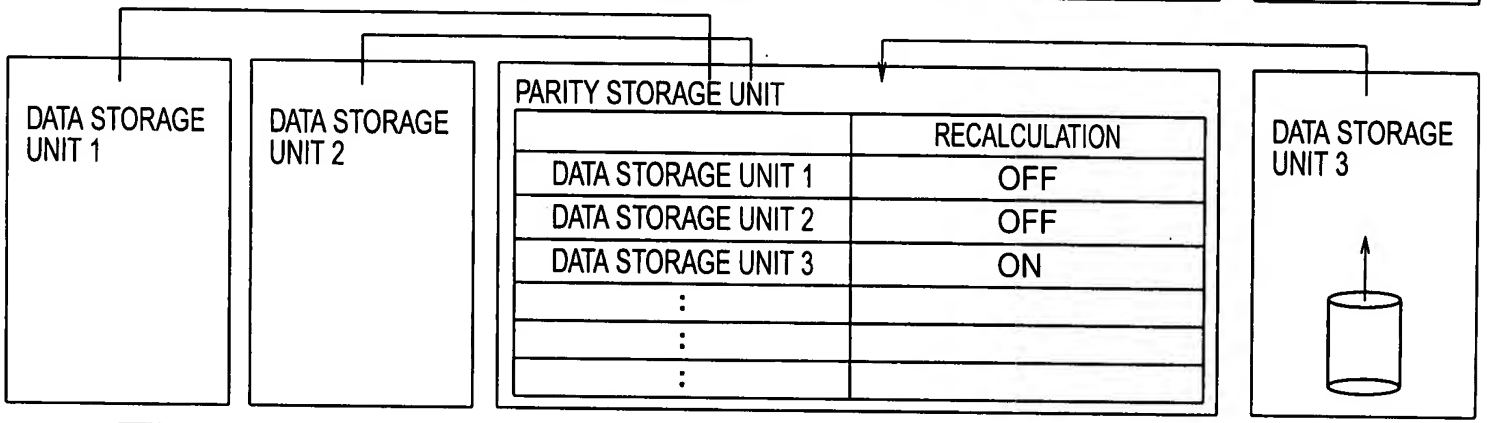


FIG. 18C

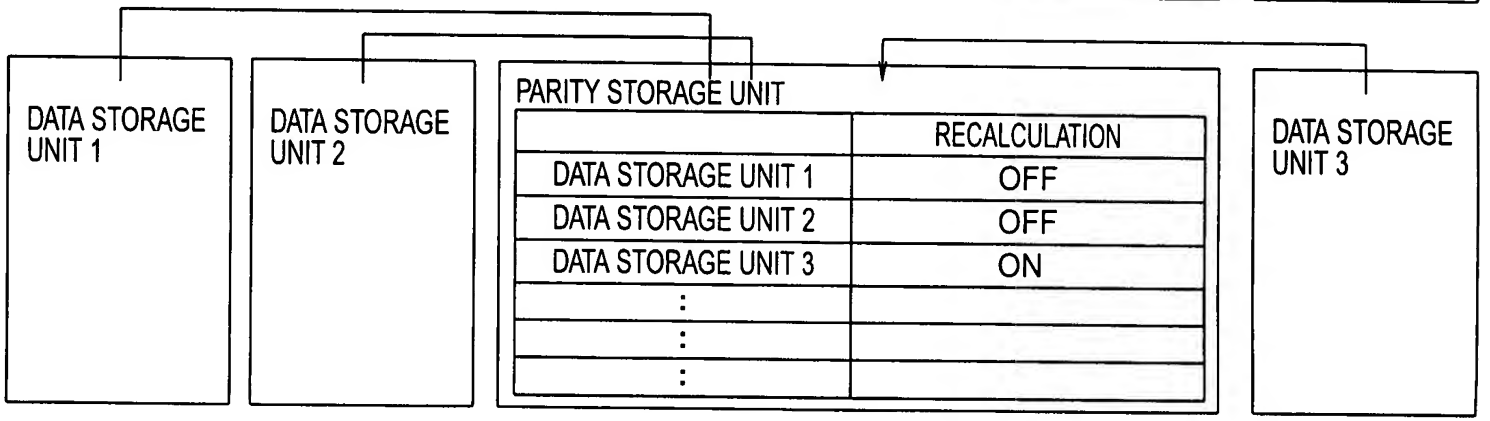
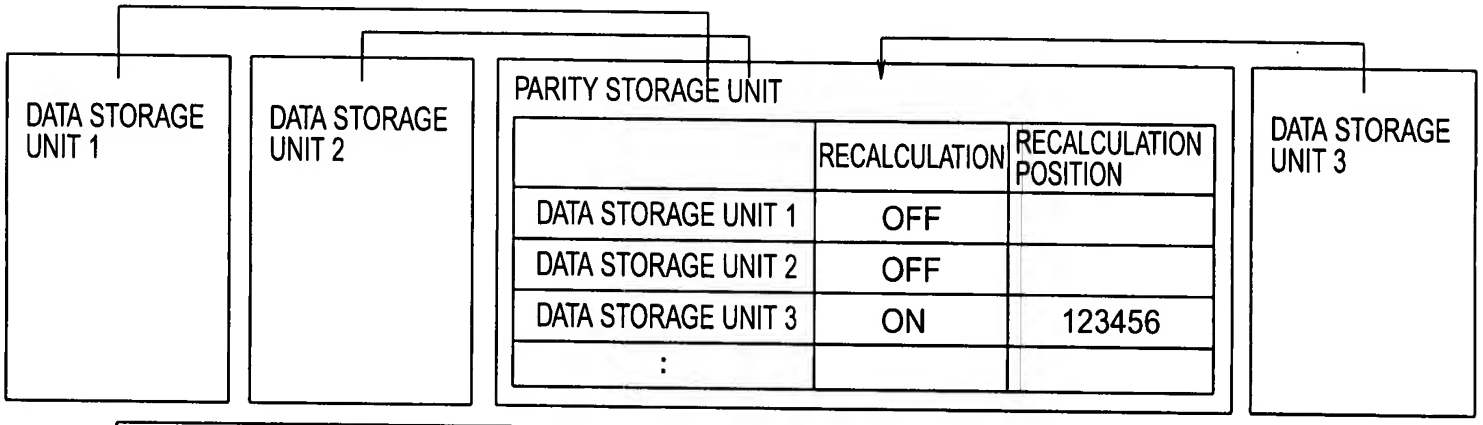
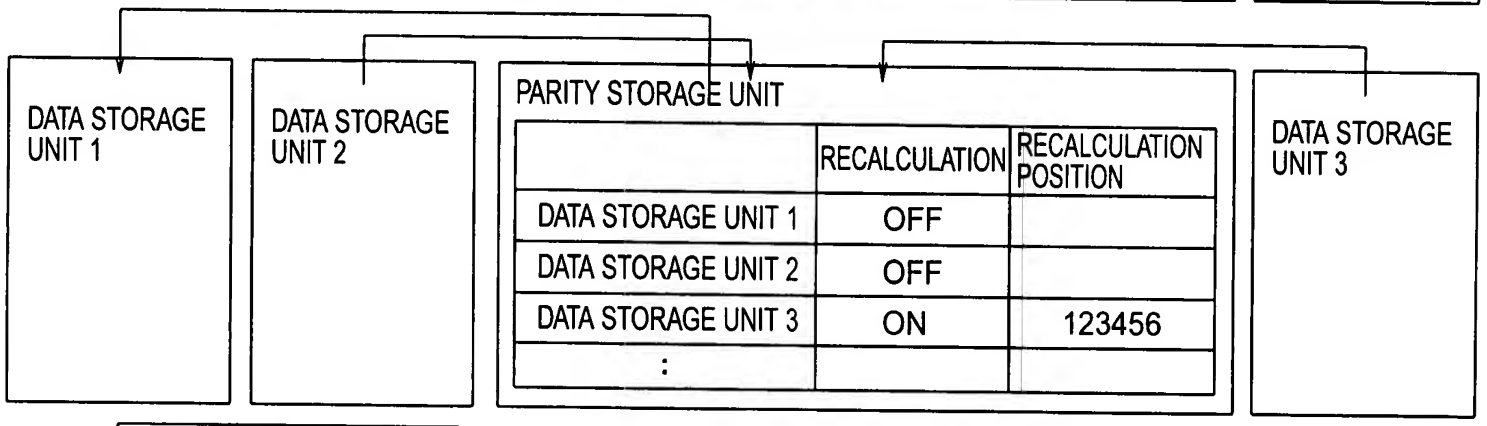


FIG. 19A



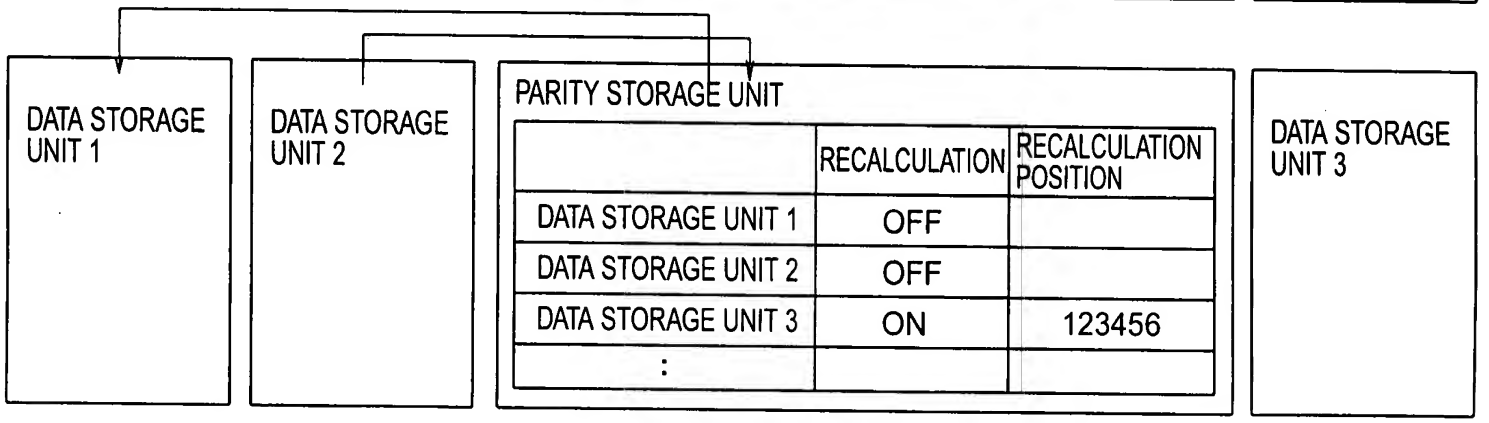
	RECALCULATION	RECALCULATION POSITION
DATA STORAGE UNIT 1	OFF	
DATA STORAGE UNIT 2	OFF	
DATA STORAGE UNIT 3	ON	123456
:		

FIG. 19B



	RECALCULATION	RECALCULATION POSITION
DATA STORAGE UNIT 1	OFF	
DATA STORAGE UNIT 2	OFF	
DATA STORAGE UNIT 3	ON	123456
:		

FIG. 19C



	RECALCULATION	RECALCULATION POSITION
DATA STORAGE UNIT 1	OFF	
DATA STORAGE UNIT 2	OFF	
DATA STORAGE UNIT 3	ON	123456
:		

FIG. 20A

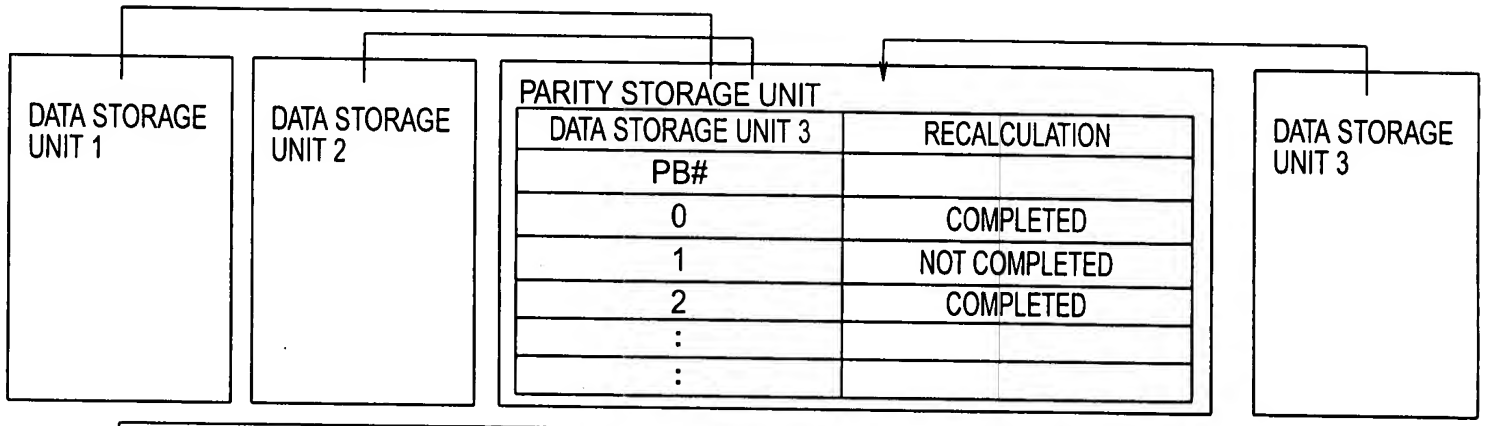


FIG. 20B

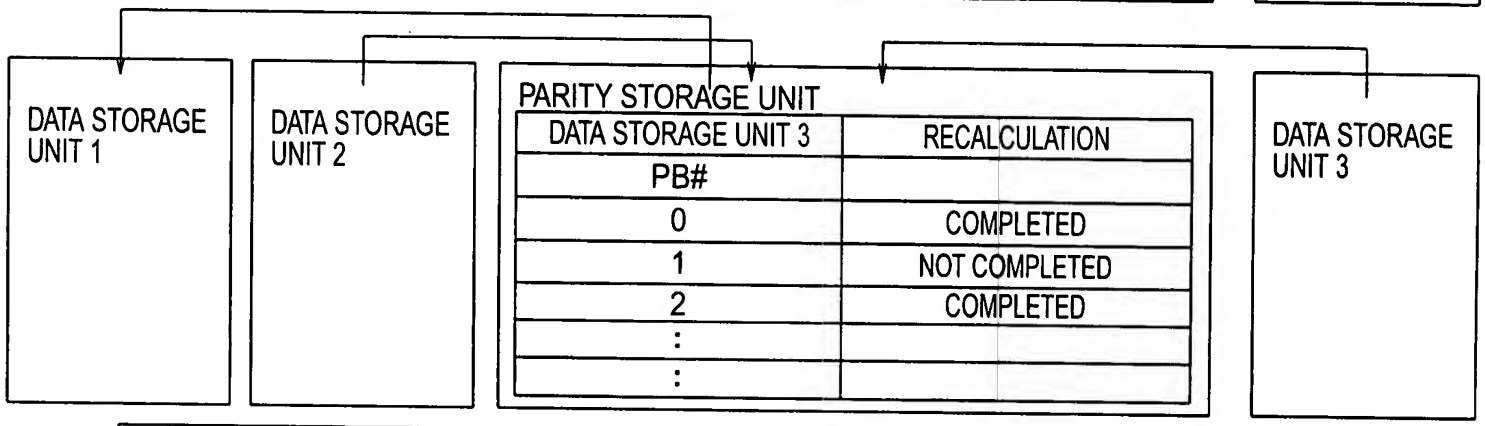


FIG. 20C

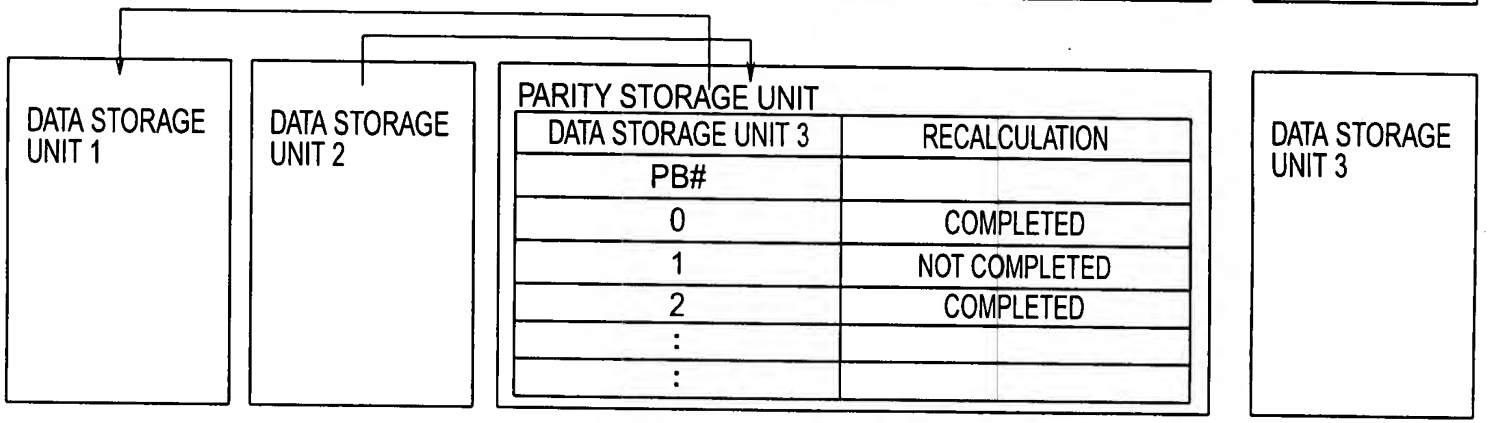


FIG. 21

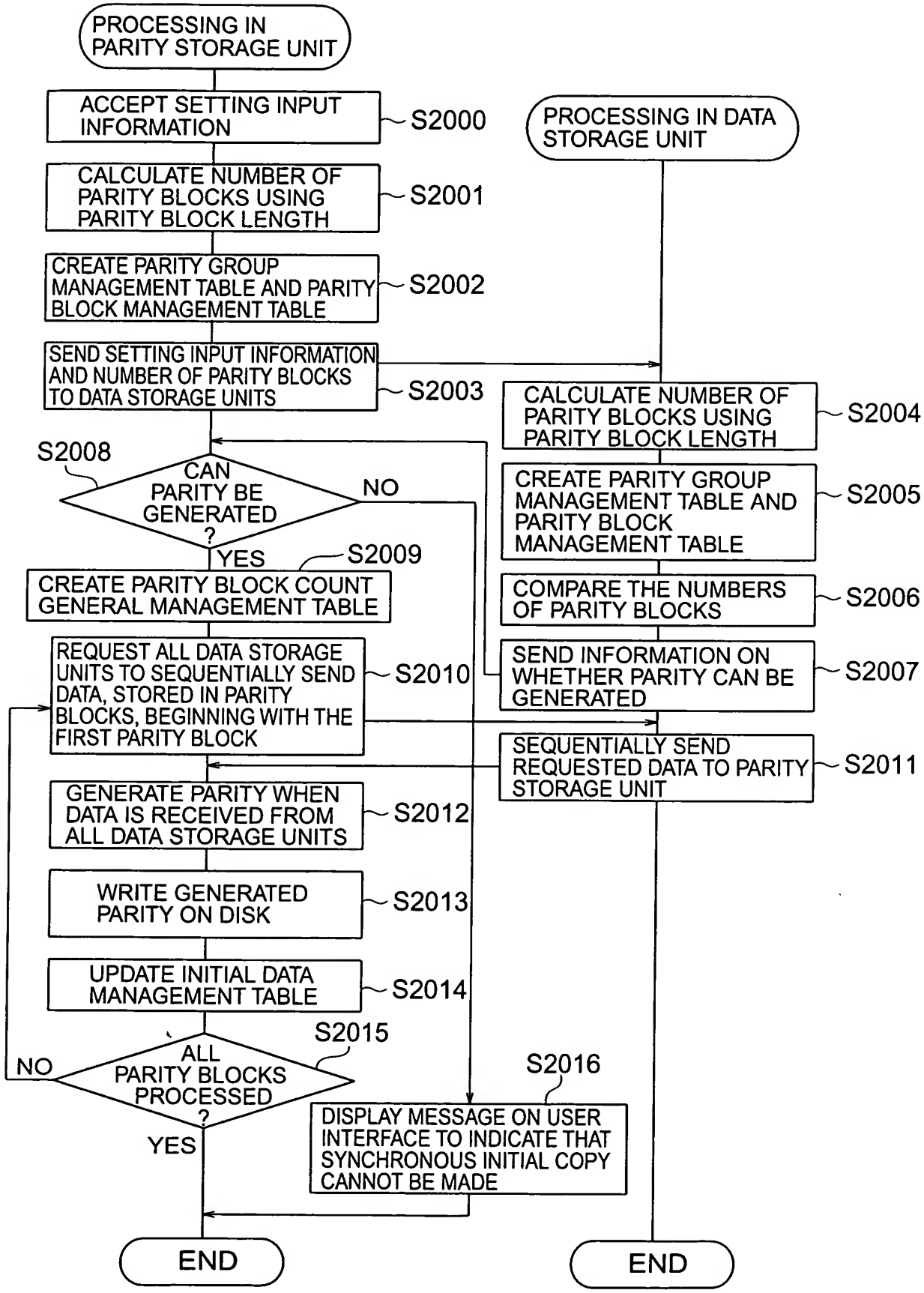

PROCESSING IN PARITY STORAGE UNIT
ACCEPT SETTING INPUT INFORMATION
S2000
CALCULATE NUMBER OF PARITY BLOCKS USING PARITY BLOCK LENGTH
S2001
CREATE PARITY GROUP MANAGEMENT TABLE AND PARITY BLOCK MANAGEMENT TABLE
S2002
SEND SETTING INPUT INFORMATION AND NUMBER OF PARITY BLOCKS TO DATA STORAGE UNITS
S2003
S2008
CAN PARITY BE GENERATED ?
NO
YES
S2009
CREATE PARITY BLOCK COUNT GENERAL MANAGEMENT TABLE
REQUEST ALL DATA STORAGE UNITS TO SEQUENTIALLY SEND DATA, STORED IN PARITY BLOCKS, BEGINNING WITH THE FIRST PARITY BLOCK
S2010
GENERATE PARITY WHEN DATA IS RECEIVED FROM ALL DATA STORAGE UNITS
S2012
WRITE GENERATED PARITY ON DISK
S2013
UPDATE INITIAL DATA MANAGEMENT TABLE
S2014
S2015
ALL PARITY BLOCKS PROCESSED ?
NO
YES
S2016
DISPLAY MESSAGE ON USER INTERFACE TO INDICATE THAT SYNCHRONOUS INITIAL COPY CANNOT BE MADE
END
PROCESSING IN DATA STORAGE UNIT
CALCULATE NUMBER OF PARITY BLOCKS USING PARITY BLOCK LENGTH
S2004
CREATE PARITY GROUP MANAGEMENT TABLE AND PARITY BLOCK MANAGEMENT TABLE
S2005
COMPARE THE NUMBERS OF PARITY BLOCKS
S2006
SEND INFORMATION ON WHETHER PARITY CAN BE GENERATED
S2007
SEQUENTIALLY SEND REQUESTED DATA TO PARITY STORAGE UNIT
S2011
END

FIG. 22A

PARITY STORAGE UNIT

PARITY BLOCK LENGTH = 512 BYTES	
STORAGE VOL#	FIRST PB#
0000	0
0001	4096
0002	16384
0003	40000
0004	81920
:	:

NUMBER OF PARITY BLOCKS =8000000

FIG. 22B

PARITY BLOCK LENGTH = 512 BYTES
NUMBER OF PARITY BLOCKS = 800000

DATA STORAGE UNIT

PARITY STORAGE UNIT

PARITY BLOCK LENGTH = 512 BYTES	
STORAGE VOL#	FIRST PB#
0000	0
0001	4096
0002	16384
0003	40000
0004	81920
:	:

NUMBER OF PARITY BLOCKS = 8000000

FIG. 22C

DATA STORAGE UNIT

PARITY BLOCK LENGTH = 512 BYTES	
STORAGE VOL#	FIRST PB#
0000	0
0001	5000
0002	8000
0003	10000
0004	20000
:	:

NUMBER OF PARITY BLOCKS = 5000000

PARITY STORAGE UNIT

PARITY BLOCK LENGTH = 512 BYTES	
STORAGE VOL#	FIRST PB#
0000	0
0001	4096
0002	16384
0003	40000
0004	81920
:	:

NUMBER OF PARITY BLOCKS = 8000000

FIG. 22D

CONNECTABLE

DATA STORAGE UNIT

PARITY BLOCK LENGTH = 512 BYTES	
STORAGE VOL#	FIRST PB#
0000	0
0001	5000
0002	8000
0003	10000
0004	20000
:	:

NUMBER OF PARITY BLOCKS = 5000000

PARITY STORAGE UNIT

PARITY BLOCK LENGTH = 512 BYTES	
STORAGE VOL#	FIRST PB#
0000	0
0001	4096
0002	16384
0003	40000
0004	81920
:	:

NUMBER OF PARITY BLOCKS = 8000000

FIG. 23

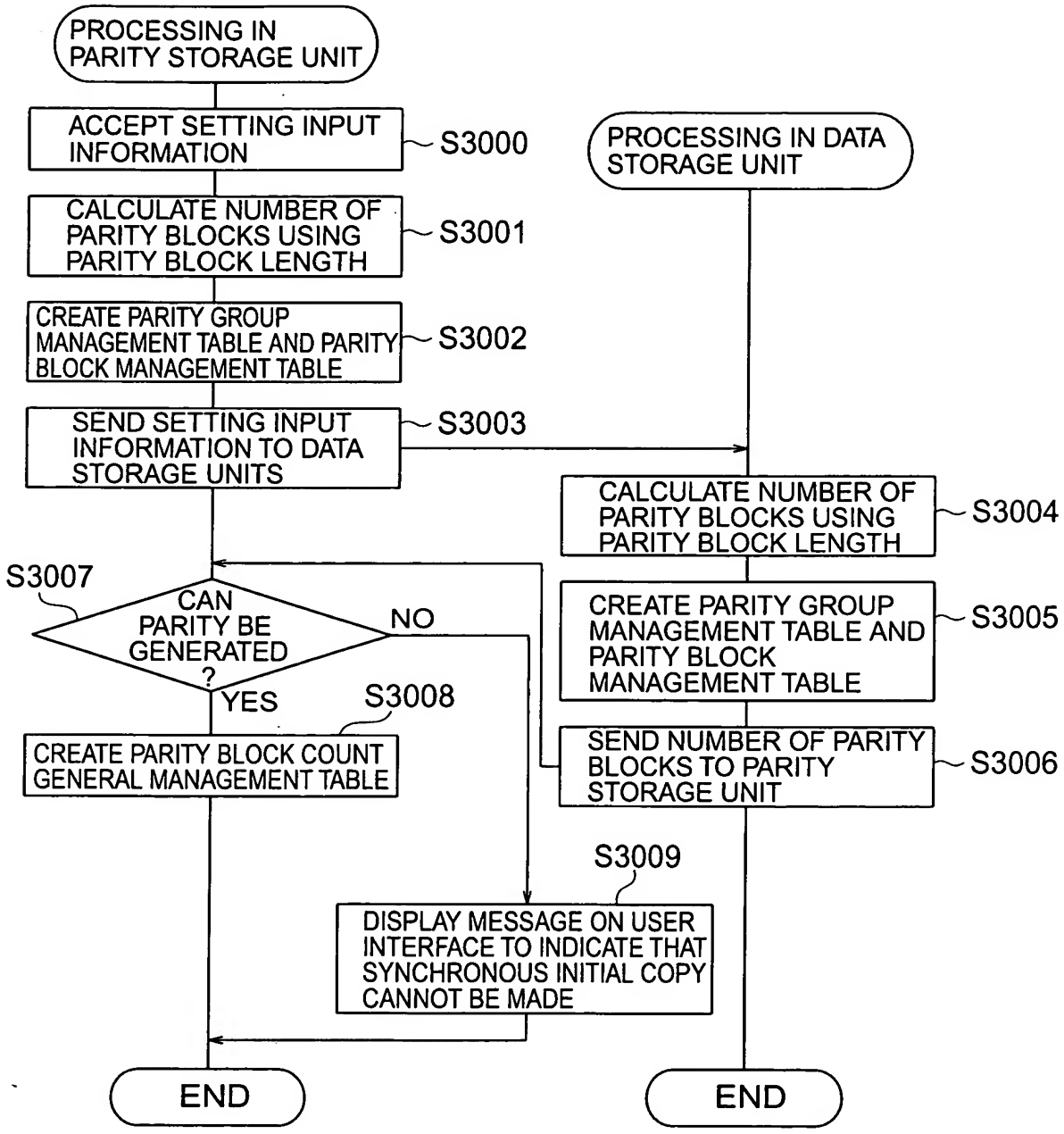

PROCESSING IN PARITY STORAGE UNIT
ACCEPT SETTING INPUT INFORMATION
S3000
CALCULATE NUMBER OF PARITY BLOCKS USING PARITY BLOCK LENGTH
S3001
CREATE PARITY GROUP MANAGEMENT TABLE AND PARITY BLOCK MANAGEMENT TABLE
S3002
SEND SETTING INPUT INFORMATION TO DATA STORAGE UNITS
S3003
PROCESSING IN DATA STORAGE UNIT
CALCULATE NUMBER OF PARITY BLOCKS USING PARITY BLOCK LENGTH
S3004
CREATE PARITY GROUP MANAGEMENT TABLE AND PARITY BLOCK MANAGEMENT TABLE
S3005
SEND NUMBER OF PARITY BLOCKS TO PARITY STORAGE UNIT
S3006
S3007
CAN PARITY BE GENERATED ?
NO
YES
S3008
CREATE PARITY BLOCK COUNT GENERAL MANAGEMENT TABLE
S3009
DISPLAY MESSAGE ON USER INTERFACE TO INDICATE THAT SYNCHRONOUS INITIAL COPY CANNOT BE MADE
END
END

FIG. 24

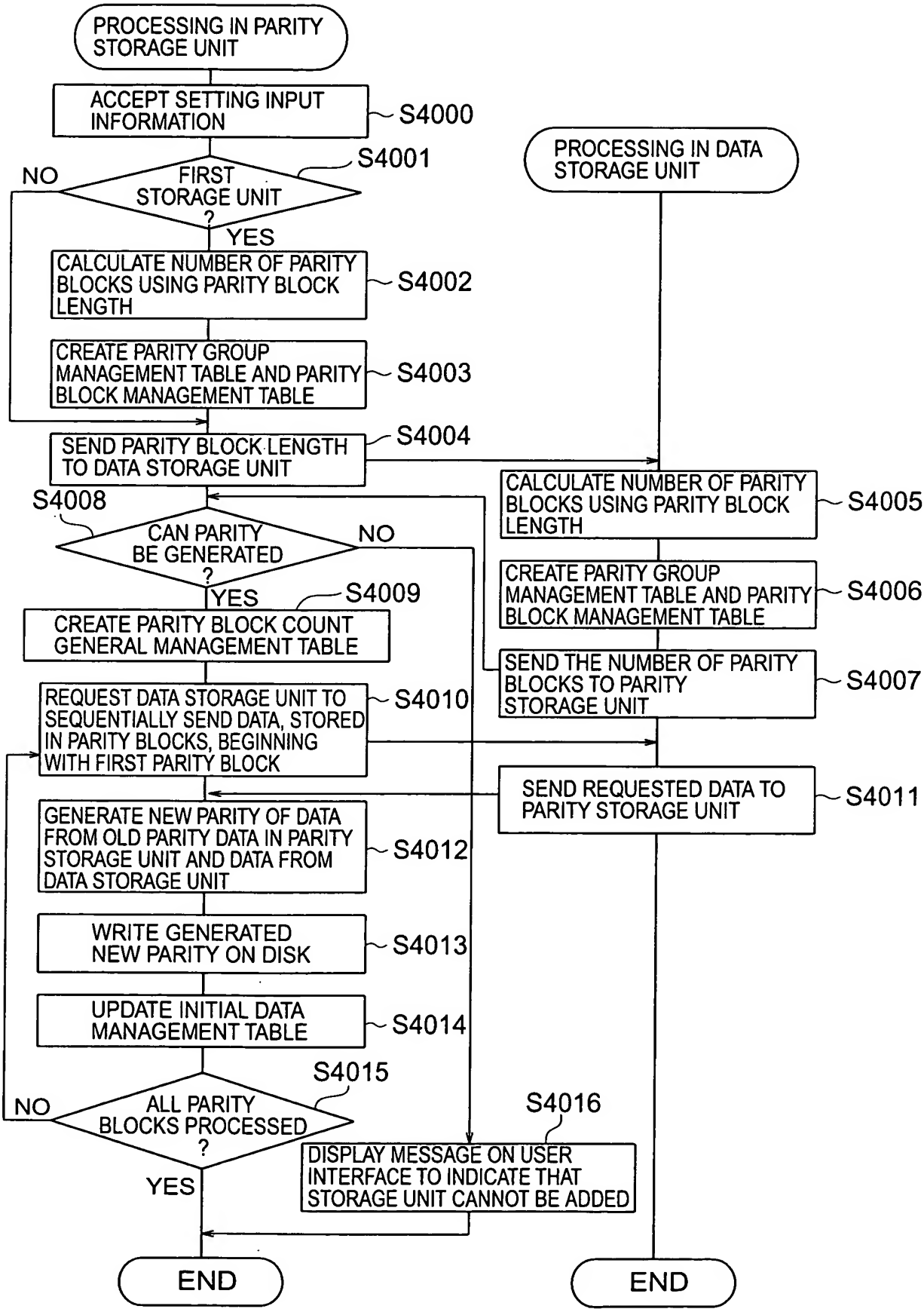

PROCESSING IN PARITY STORAGE UNIT
ACCEPT SETTING INPUT INFORMATION
S4000
FIRST STORAGE UNIT ?
S4001
NO
YES
CALCULATE NUMBER OF PARITY BLOCKS USING PARITY BLOCK LENGTH
S4002
CREATE PARITY GROUP MANAGEMENT TABLE AND PARITY BLOCK MANAGEMENT TABLE
S4003
SEND PARITY BLOCK LENGTH TO DATA STORAGE UNIT
S4004
PROCESSING IN DATA STORAGE UNIT
CALCULATE NUMBER OF PARITY BLOCKS USING PARITY BLOCK LENGTH
S4005
CREATE PARITY GROUP MANAGEMENT TABLE AND PARITY BLOCK MANAGEMENT TABLE
S4006
SEND THE NUMBER OF PARITY BLOCKS TO PARITY STORAGE UNIT
S4007
S4008
CAN PARITY BE GENERATED ?
NO
YES
S4009
CREATE PARITY BLOCK COUNT GENERAL MANAGEMENT TABLE
REQUEST DATA STORAGE UNIT TO SEQUENTIALLY SEND DATA, STORED IN PARITY BLOCKS, BEGINNING WITH FIRST PARITY BLOCK
S4010
SEND REQUESTED DATA TO PARITY STORAGE UNIT
S4011
GENERATE NEW PARITY OF DATA FROM OLD PARITY DATA IN PARITY STORAGE UNIT AND DATA FROM DATA STORAGE UNIT
S4012
WRITE GENERATED NEW PARITY ON DISK
S4013
UPDATE INITIAL DATA MANAGEMENT TABLE
S4014
S4015
ALL PARITY BLOCKS PROCESSED ?
NO
YES
S4016
DISPLAY MESSAGE ON USER INTERFACE TO INDICATE THAT STORAGE UNIT CANNOT BE ADDED
END
END

FIG. 25

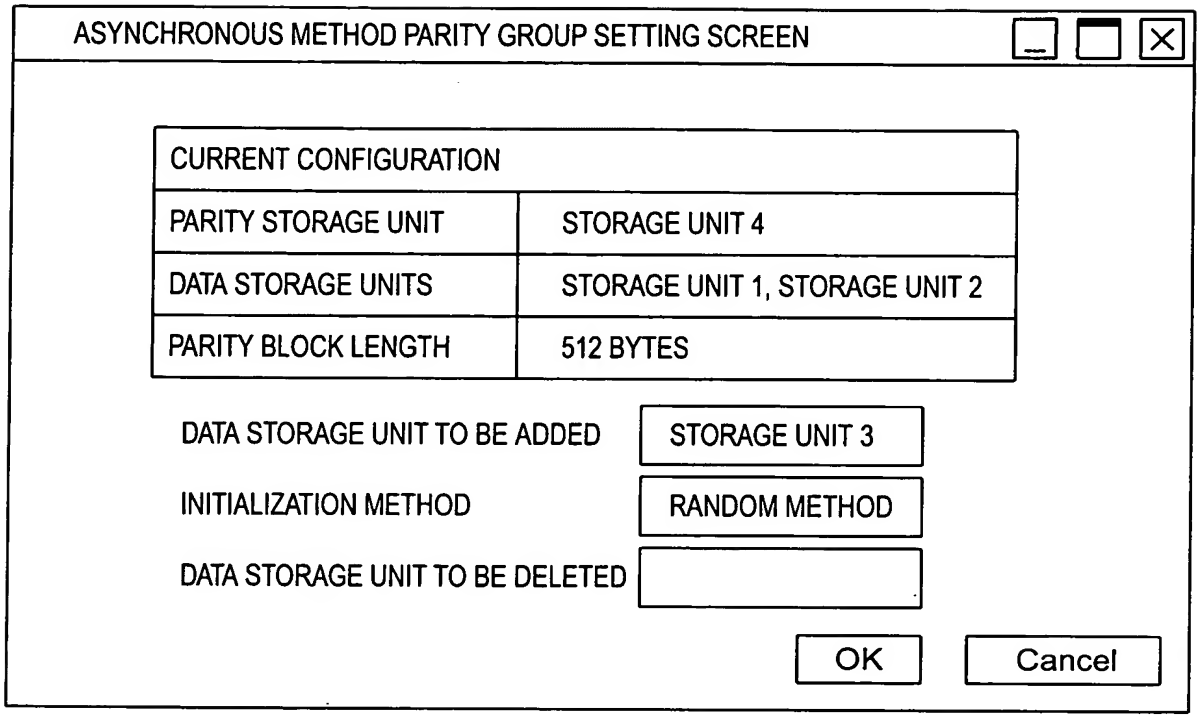

ASYNCHRONOUS METHOD PARITY GROUP SETTING SCREEN
CURRENT CONFIGURATION
PARITY STORAGE UNIT
STORAGE UNIT 4
DATA STORAGE UNITS
STORAGE UNIT 1, STORAGE UNIT 2
PARITY BLOCK LENGTH
512 BYTES
DATA STORAGE UNIT TO BE ADDED
STORAGE UNIT 3
INITIALIZATION METHOD
RANDOM METHOD
DATA STORAGE UNIT TO BE DELETED
OK
Cancel

FIG. 26

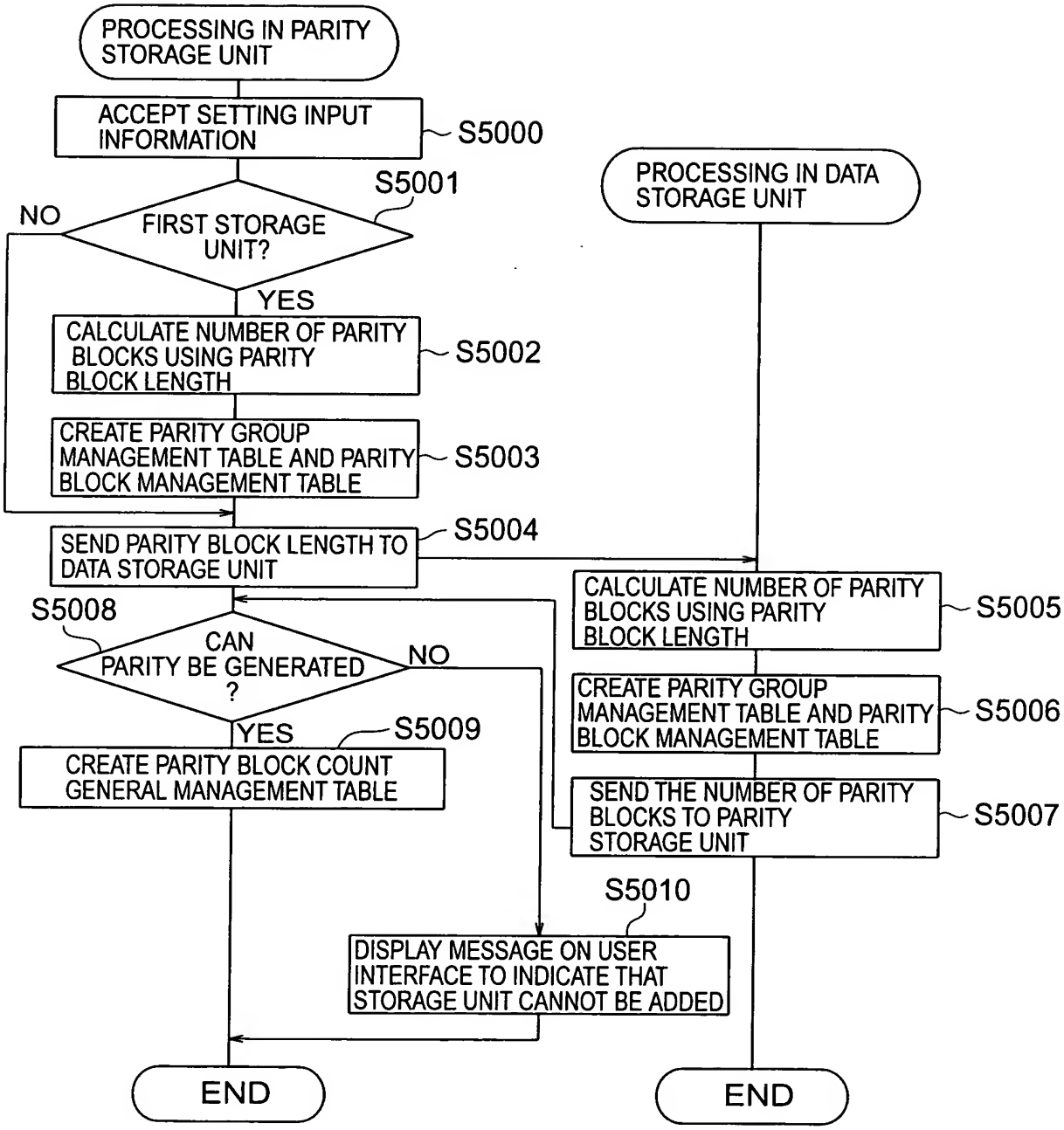

PROCESSING IN PARITY STORAGE UNIT
ACCEPT SETTING INPUT INFORMATION
S5000
S5001
NO
FIRST STORAGE UNIT?
YES
CALCULATE NUMBER OF PARITY BLOCKS USING PARITY BLOCK LENGTH
S5002
CREATE PARITY GROUP MANAGEMENT TABLE AND PARITY BLOCK MANAGEMENT TABLE
S5003
SEND PARITY BLOCK LENGTH TO DATA STORAGE UNIT
S5004
S5008
CAN PARITY BE GENERATED ?
NO
YES
S5009
CREATE PARITY BLOCK COUNT GENERAL MANAGEMENT TABLE
END
PROCESSING IN DATA STORAGE UNIT
CALCULATE NUMBER OF PARITY BLOCKS USING PARITY BLOCK LENGTH
S5005
CREATE PARITY GROUP MANAGEMENT TABLE AND PARITY BLOCK MANAGEMENT TABLE
S5006
SEND THE NUMBER OF PARITY BLOCKS TO PARITY STORAGE UNIT
S5007
S5010
DISPLAY MESSAGE ON USER INTERFACE TO INDICATE THAT STORAGE UNIT CANNOT BE ADDED
END

FIG. 27

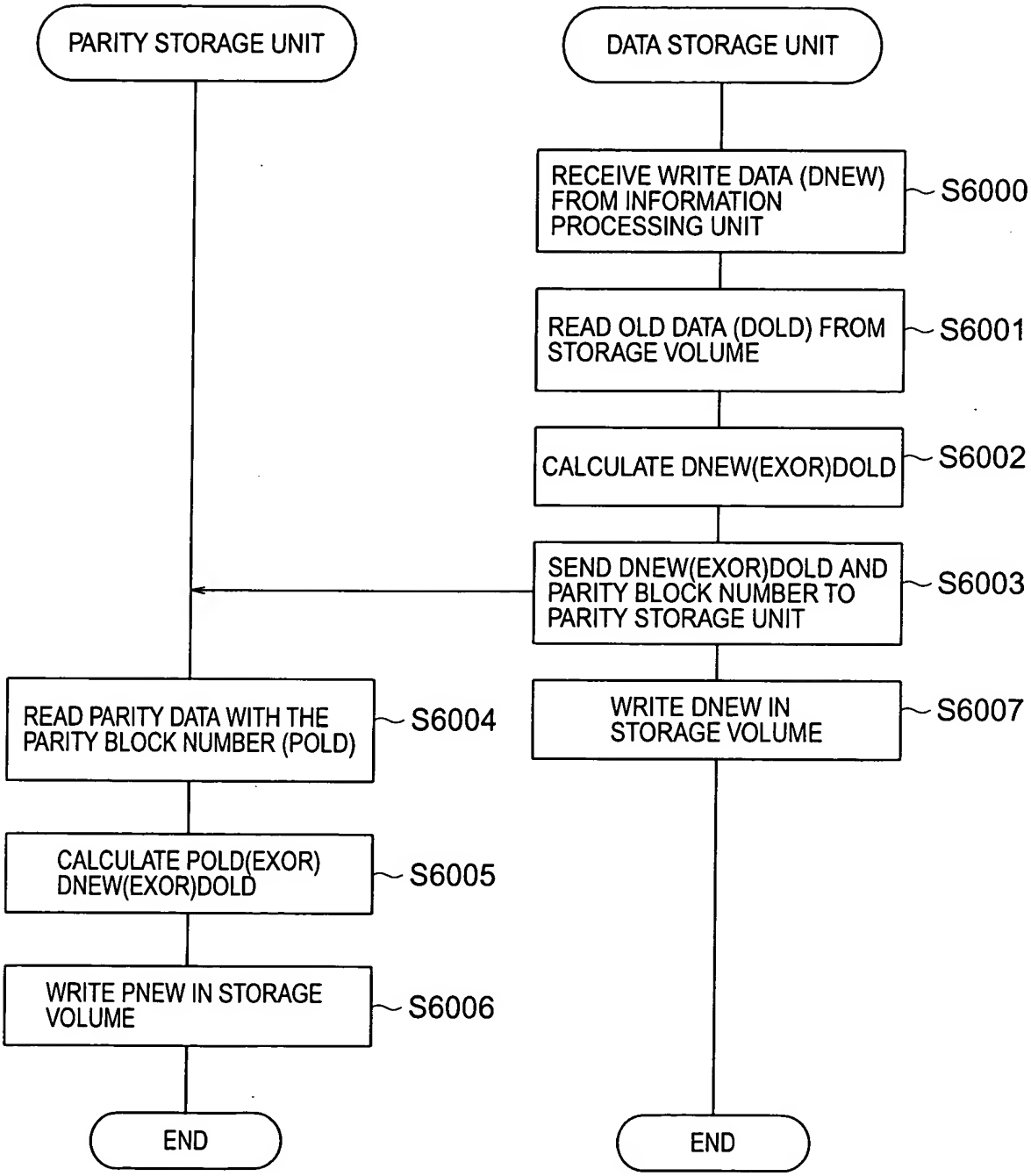

PARITY STORAGE UNIT
DATA STORAGE UNIT
RECEIVE WRITE DATA (DNEW) FROM INFORMATION PROCESSING UNIT
S6000
READ OLD DATA (DOLD) FROM STORAGE VOLUME
S6001
CALCULATE DNEW(EXOR)DOLD
S6002
SEND DNEW(EXOR)DOLD AND PARITY BLOCK NUMBER TO PARITY STORAGE UNIT
S6003
READ PARITY DATA WITH THE PARITY BLOCK NUMBER (POLD)
S6004
WRITE DNEW IN STORAGE VOLUME
S6007
CALCULATE POLD(EXOR) DNEW(EXOR)DOLD
S6005
WRITE PNEW IN STORAGE VOLUME
S6006
END
END

FIG. 28

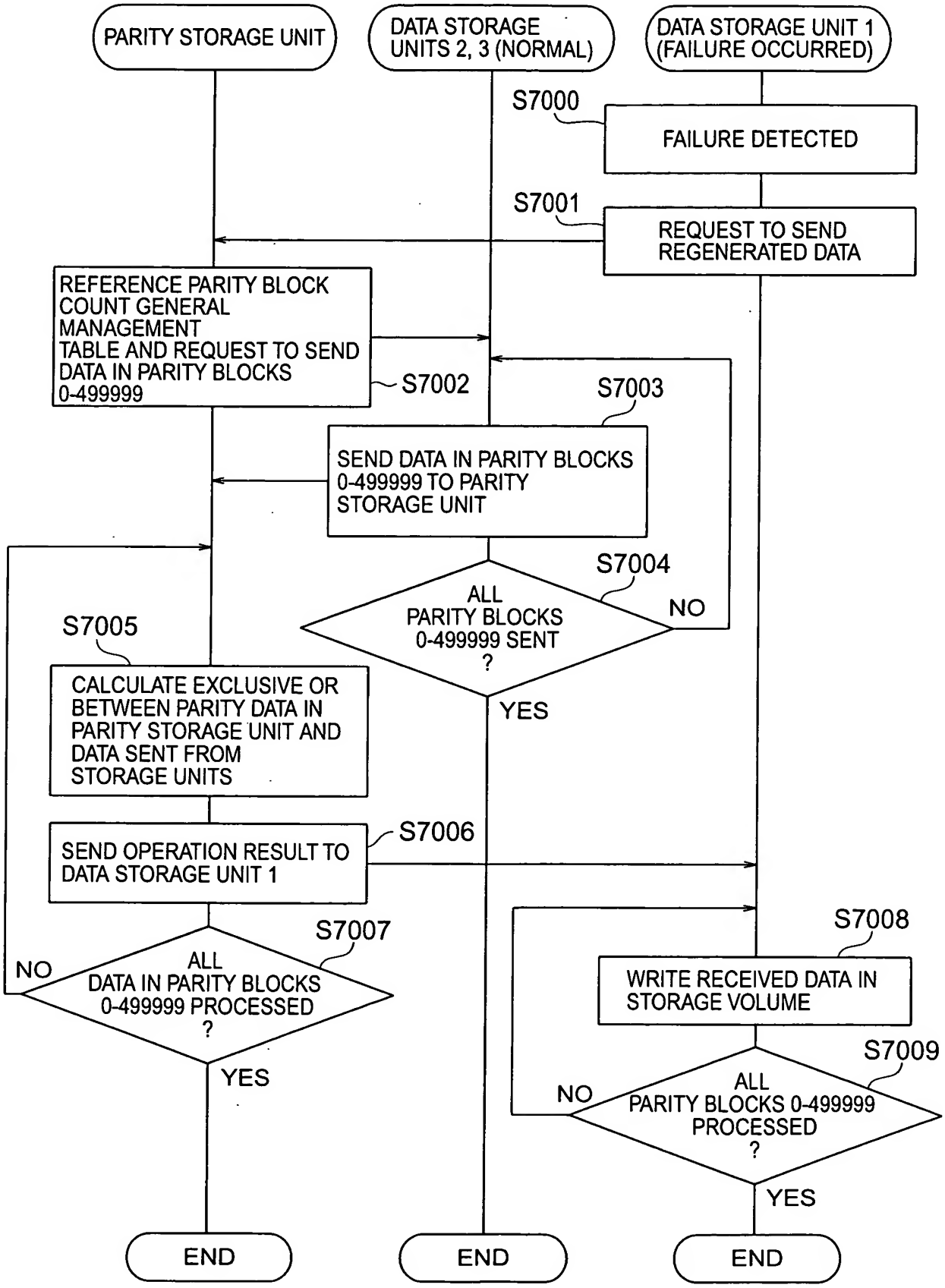
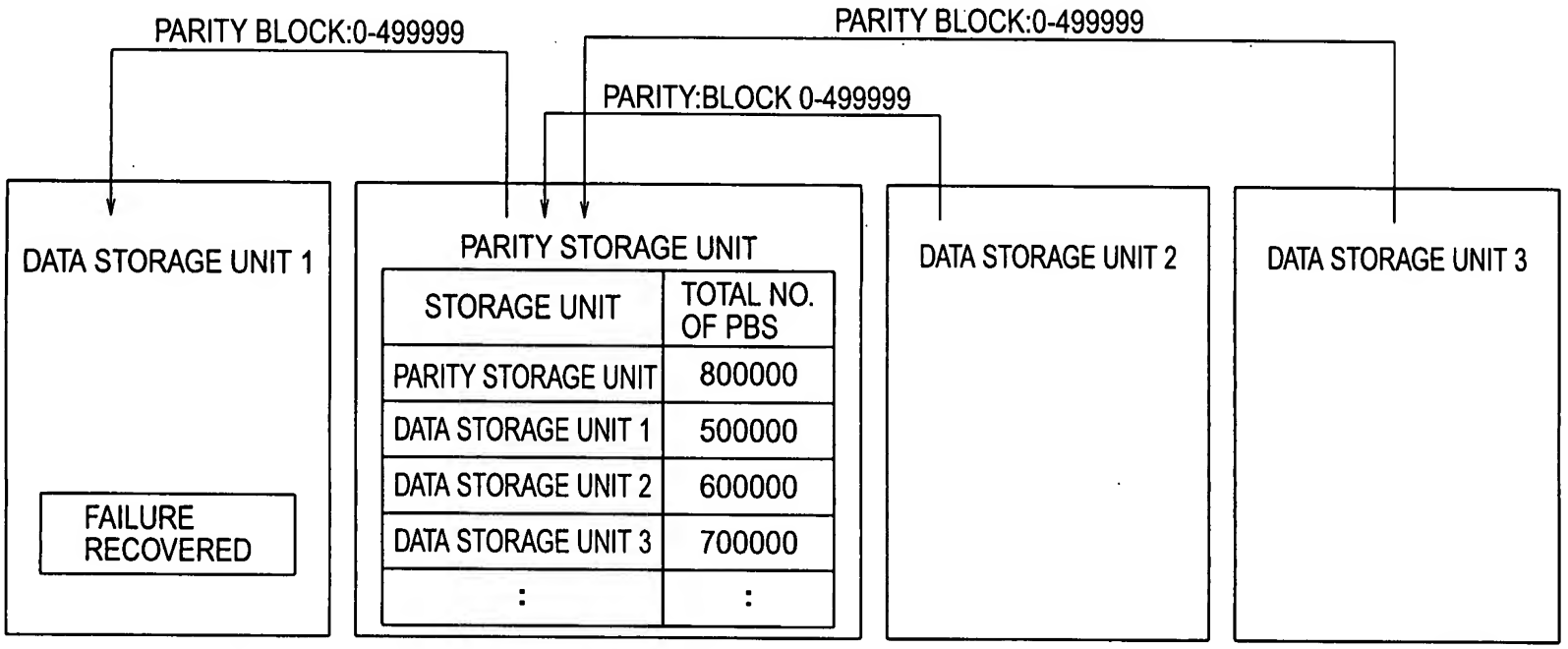

PARITY STORAGE UNIT
DATA STORAGE UNITS 2, 3 (NORMAL)
DATA STORAGE UNIT 1 (FAILURE OCCURRED)
S7000
FAILURE DETECTED
S7001
REQUEST TO SEND REGENERATED DATA
REFERENCE PARITY BLOCK COUNT GENERAL MANAGEMENT TABLE AND REQUEST TO SEND DATA IN PARITY BLOCKS 0-499999
S7002
S7003
SEND DATA IN PARITY BLOCKS 0-499999 TO PARITY STORAGE UNIT
S7004
ALL PARITY BLOCKS 0-499999 SENT ?
NO
YES
S7005
CALCULATE EXCLUSIVE OR BETWEEN PARITY DATA IN PARITY STORAGE UNIT AND DATA SENT FROM STORAGE UNITS
S7006
SEND OPERATION RESULT TO DATA STORAGE UNIT 1
S7007
NO
ALL DATA IN PARITY BLOCKS 0-499999 PROCESSED ?
YES
S7008
WRITE RECEIVED DATA IN STORAGE VOLUME
S7009
NO
ALL PARITY BLOCKS 0-499999 PROCESSED ?
YES
END
END
END

FIG. 29



STORAGE UNIT	TOTAL NO. OF PBS
PARITY STORAGE UNIT	800000
DATA STORAGE UNIT 1	500000
DATA STORAGE UNIT 2	600000
DATA STORAGE UNIT 3	700000
:	:

FIG. 30

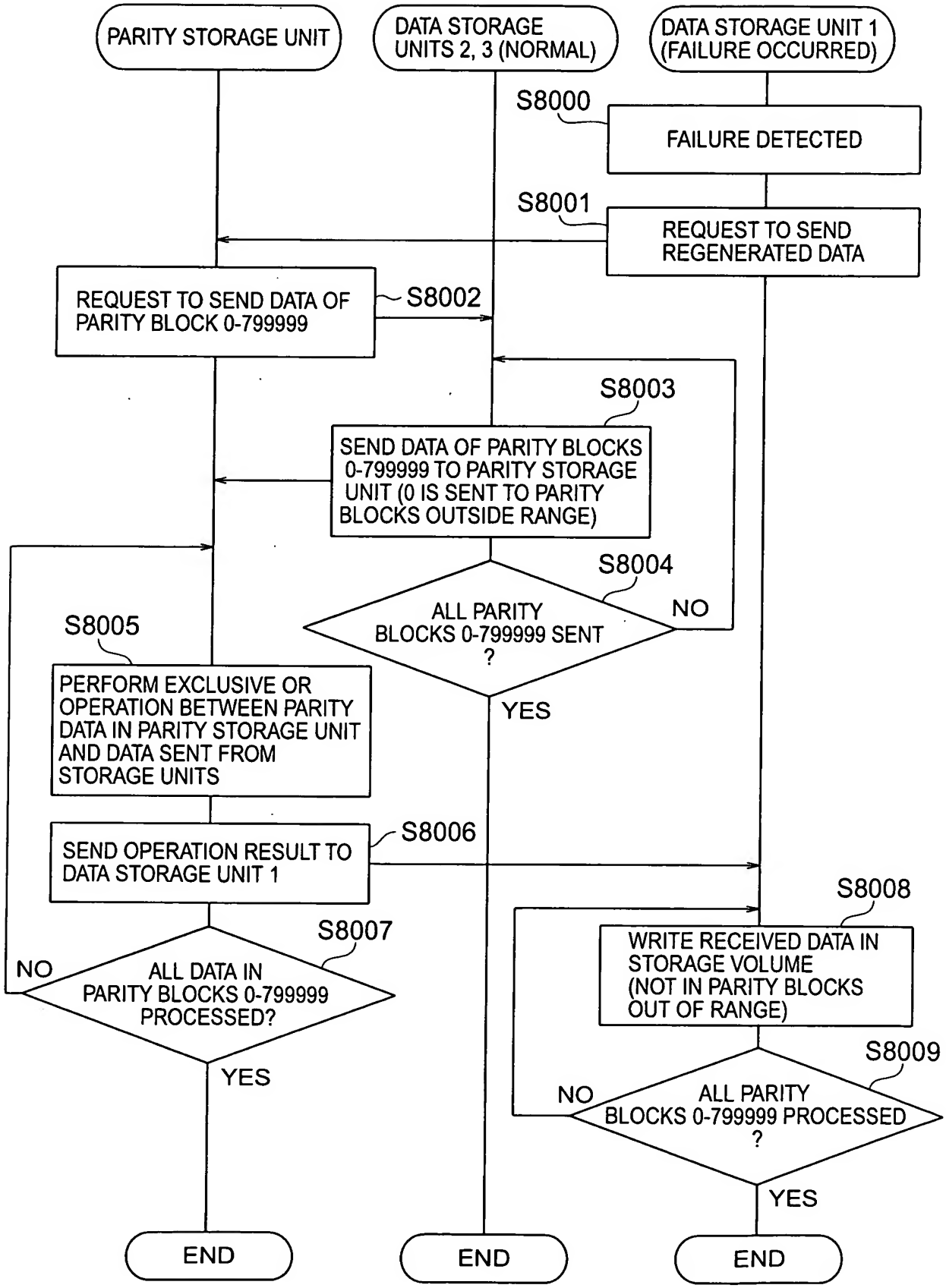

PARITY STORAGE UNIT
DATA STORAGE UNITS 2, 3 (NORMAL)
DATA STORAGE UNIT 1 (FAILURE OCCURRED)
S8000
FAILURE DETECTED
S8001
REQUEST TO SEND REGENERATED DATA
REQUEST TO SEND DATA OF PARITY BLOCK 0-799999
S8002
S8003
SEND DATA OF PARITY BLOCKS 0-799999 TO PARITY STORAGE UNIT (0 IS SENT TO PARITY BLOCKS OUTSIDE RANGE)
S8004
ALL PARITY BLOCKS 0-799999 SENT ?
NO
YES
S8005
PERFORM EXCLUSIVE OR OPERATION BETWEEN PARITY DATA IN PARITY STORAGE UNIT AND DATA SENT FROM STORAGE UNITS
SEND OPERATION RESULT TO DATA STORAGE UNIT 1
S8006
S8007
NO
ALL DATA IN PARITY BLOCKS 0-799999 PROCESSED?
YES
S8008
WRITE RECEIVED DATA IN STORAGE VOLUME (NOT IN PARITY BLOCKS OUT OF RANGE)
S8009
NO
ALL PARITY BLOCKS 0-799999 PROCESSED ?
YES
END
END
END

FIG. 31

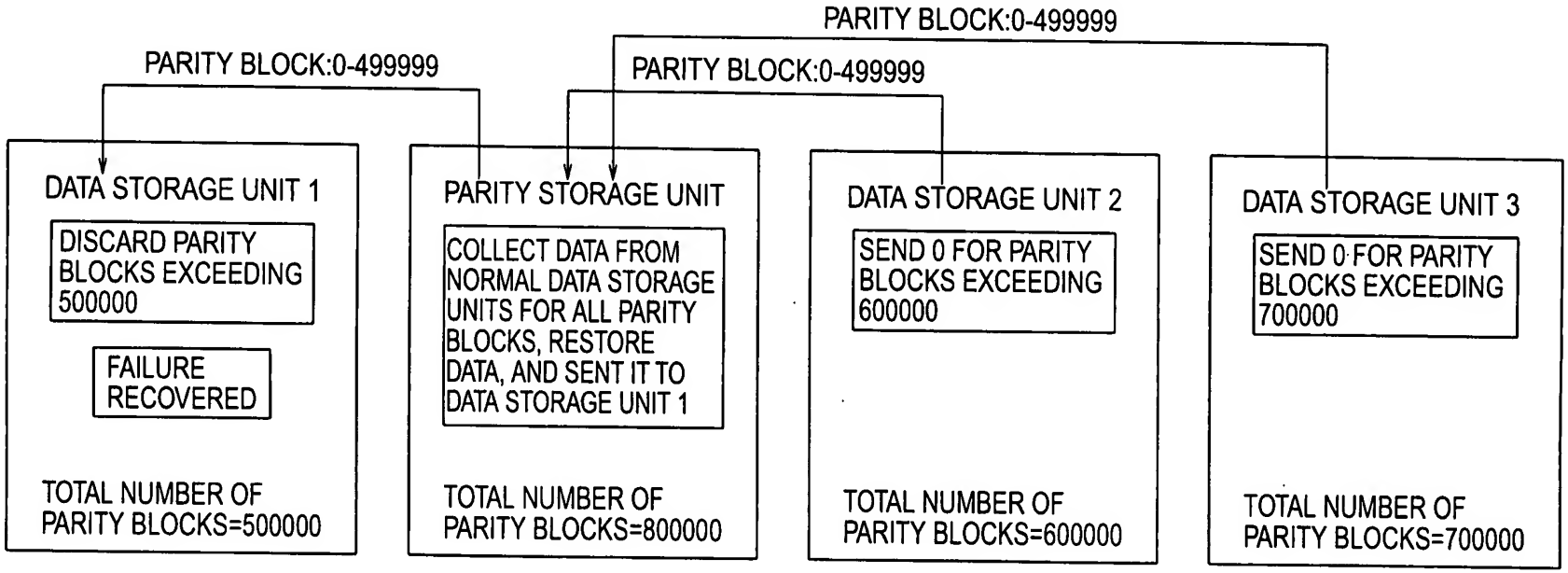

PARITY BLOCK:0-499999
PARITY BLOCK:0-499999
PARITY BLOCK:0-499999
DATA STORAGE UNIT 1
DISCARD PARITY BLOCKS EXCEEDING 500000
FAILURE RECOVERED
TOTAL NUMBER OF PARITY BLOCKS=500000
PARITY STORAGE UNIT
COLLECT DATA FROM NORMAL DATA STORAGE UNITS FOR ALL PARITY BLOCKS, RESTORE DATA, AND SENT IT TO DATA STORAGE UNIT 1
TOTAL NUMBER OF PARITY BLOCKS=800000
DATA STORAGE UNIT 2
SEND 0 FOR PARITY BLOCKS EXCEEDING 600000
TOTAL NUMBER OF PARITY BLOCKS=600000
DATA STORAGE UNIT 3
SEND 0 FOR PARITY BLOCKS EXCEEDING 700000
TOTAL NUMBER OF PARITY BLOCKS=700000

FIG. 32

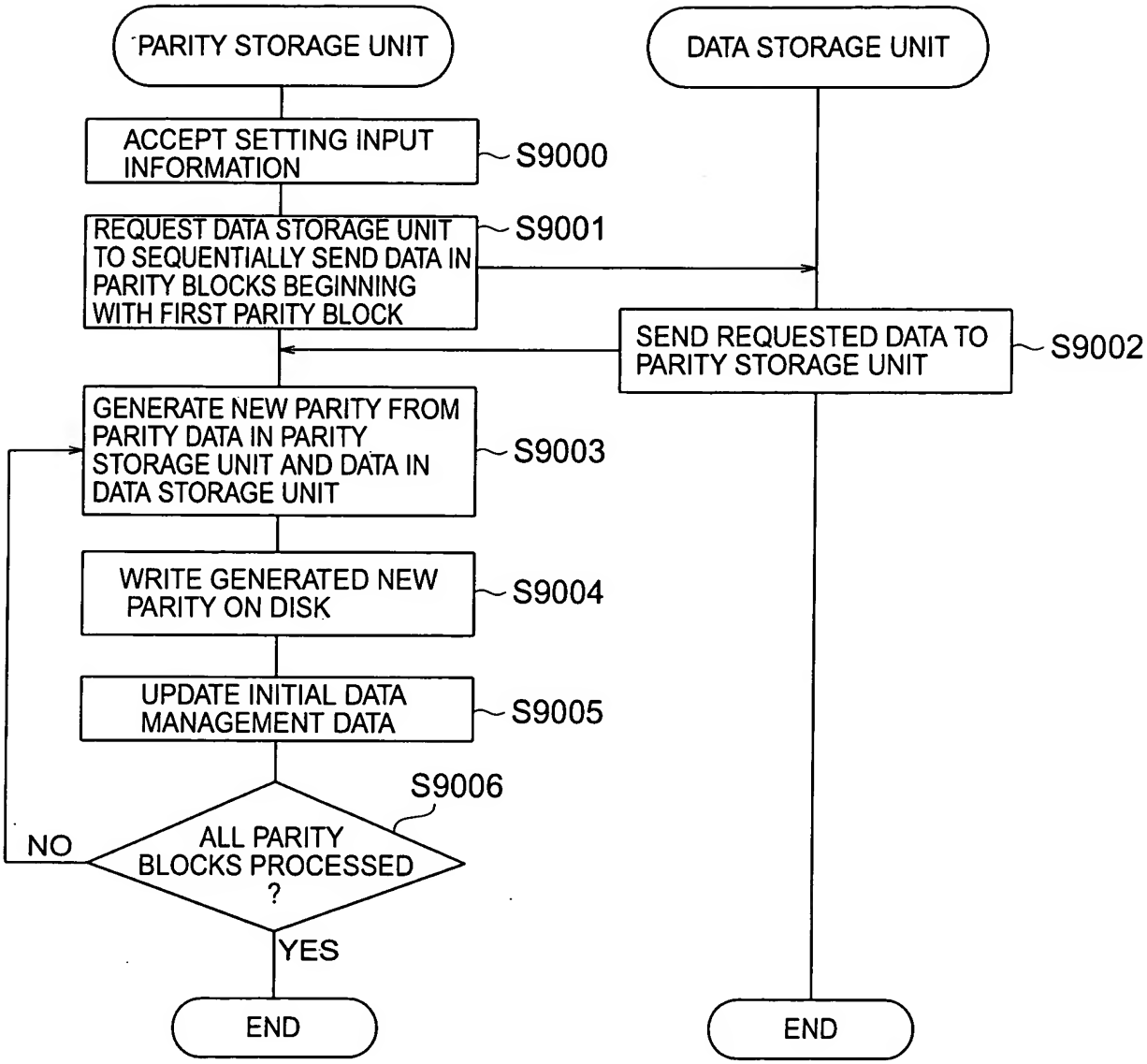


FIG. 33

PARITY BLOCK NUMBER	STATUS INFORMATION	DATA